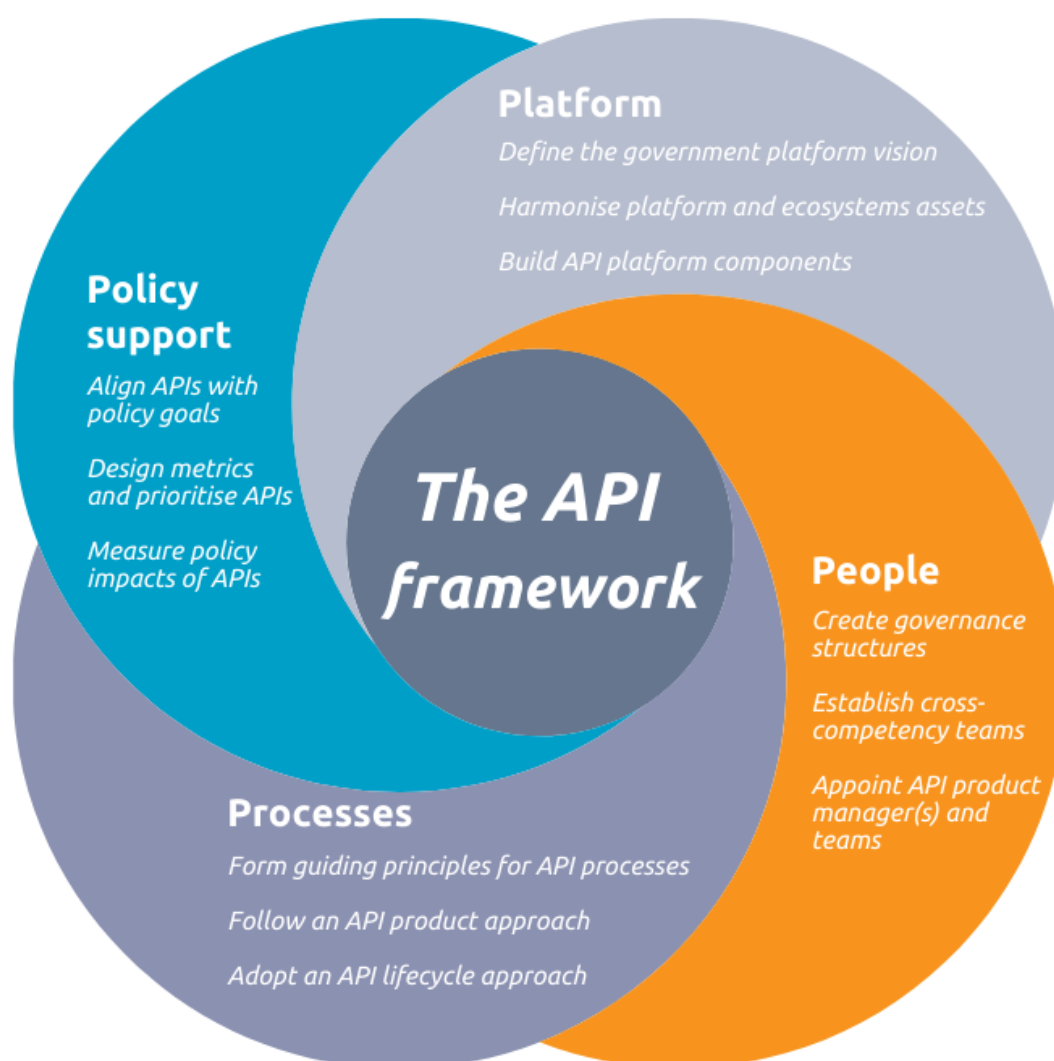# JRC TECHNICAL REPORT

An Application Programming Interface (API) framework for digital government

Boyd, M., Vaccari, L., Posada, M., Gattwinkel, D.

How to cite this report: Boyd, M., Vaccari, L., Posada, M. and Gattwinkel, D., *An Application Programming Interface (API) framework for digital government*, EUR 30226 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18980-0, doi:10.2760/772503, JRC120715.

Contents

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Abstract

The digital transformation of society obliges governments to evolve towards increasingly complex digital environments. These environments require strong coordination efforts to ensure a synergistic integration of different systems and actors. Application programming interfaces (APIs) are the connective nodes of digital components and thus instrumental enablers of this integration. Yet today, the integration of digital components is often done on an 'ad hoc' basis, disregarding the potential value-added for the whole digital environment.

This work proposes a framework for a cohesive API adoption in government environments. The framework is distilled from the analysis of an extensive literature review conducted on government API adoption practices to date. The output of this analysis identifies actions to be taken by governments to improve their API infrastructure and related organisational processes. The framework offers 12 'proposals' arranged around four organisational pillars, namely, policy support, platforms and ecosystems, people, and processes. Actions are then organised into the three levels of organisational management, i.e. strategic, tactical and operational. Motivations, implementation details and a self-assessment checklist are provided for each of the proposals.

Given that the maturity of digital government structures is uneven, the framework has been designed to be flexible enough to help governments identify the specific actions they need to focus on. The work outlines the basis of an API maturity assessment tool.

1   Introduction

1.1   Context and objectives

The European Commission's Joint Research Centre (JRC) and Directorate-General for Communications Networks, Content and Technology (DG CNECT) launched the APIs4DGov study with the purpose of gaining further understanding of the current use of APIs in digital government and their added value for public services (European Commission, 2018a).

The APIs4DGov study reflects the European Commission's interest in exploring, in detail, innovative ways to improve the provision and interconnectivity of public services and the reusability of public sector data, including dynamic data in real time while safeguarding data protection and privacy concerns. In particular, the study:

> (i) assesses the digital government APIs landscape and opportunities to support the digital transformation of the public sector;
>
> (ii) identifies the added value for society and public administrations of digital government APIs (addressing the key enablers, drivers, barriers, potential risks and mitigating actions); and
>
> (iii) defines a basic Digital Government API EU framework.

The work presented in this document has been conducted within the APIs4DGov study, specifically, to fulfil the following two objectives:

— Conducting a systematic review to answer the question: **'What are the best practices, guidelines and recommendations for digital government APIs for public administrations?'**

— Performing an analysis of the available literature, and **building a robust API framework to inspire governments in their journey towards a consistent, efficient and effective adoption of APIs with a 'whole-of-government' vision.**

In addition to this report, the framework outputs include:

- **A complete list of API best practices documents analysed** (Boyd and Vaccari, 2020)**.**

- **The online tool to self-assess the adoption of the framework** (Boyd et al., 2020)**.**

1.2   Background and motivation

The digital transformation of society obliges governments to adapt to the digital era. This means that governments need to evolve towards increasingly complex digital environments. These environments require strong coordination efforts to ensure a synergic integration of different subsystems and actors. Application programming interfaces (APIs) are the connective nodes of digital components and thus instrumental enablers of this integration. Yet today, the integration of digital components is often done on an 'ad hoc' basis, disregarding the potential value-added for the whole digital environment.

APIs are technical enablers of the transformation towards digital government. Specifically, API solutions are modular, reusable, and easily scalable (near-zero marginal cost solutions). These characteristics endow API-enabled environments with high flexibility, both technically and organisationally. Technically, APIs underpin the creation of digital ecosystems and add agility to innovative processes in organisations. Organisationally, API solutions facilitate digital interactions with internal (G2G) and external (G2B, G2C) actors. Along these lines, another crucial aspect to consider is security. APIs are doors to enter digital infrastructures; thus, the security and resilience of digital environments will also depend on the robustness of the API infrastructure. Additionally, APIs are interfaces where the relationships among digital actors are defined: who can access, what they can access, and under which circumstances. This has implications for the governance perspective of digital environments. In particular, APIs technically enable the control and monitoring of dynamics among actors and systems (Ghazawneh and Henfridsson, 2013).

All in all, APIs are a necessary component in the digitalisation of government operations and processes. Moreover, the flexibility that APIs grant to digital environments can better streamline information flows to all phases of policymaking. A coordinated approach to API adoption is necessary, though, to harness the transformative potential derived from cross-fertilisation opportunities while mitigating risks derived from the

increased vulnerability that API-loosely-coupled systems may confer. In a nutshell, the definition of API strategies can assist governments in steering the organisational change management process of its digitalisation.

The policy relevance of APIs is linked (i) to their capacity to provide flexible access to digital assets, i.e. data and functionality, and also (ii) to their connective role among different actors and systems. Current regulations such as the open data directive (European Union, 2019) and the 'payment services directive (PSD2)' (European Union, 2018) explicitly or implicitly mention the use of API solutions. Moreover, the creation of resilient and competitive digital ecosystems, which are underpinned by APIs, is highlighted in several European strategy documents. For instance, under the 'A European strategy for data' Communication (European Commission, 2020a) the European Commission will 'explore the need for legislative action on issues that affect relations between actors in the data-agile economy'. Moreover, the European 'Industrial strategy' (European Commission, 2020b) stresses the need for a 'partnership approach to the governance of industrial ecosystems' to cross-fertilise products and services among sectors. Also, the 'SME Strategy for a sustainable and digital Europe' mentions the need to 'Empower SMEs to reap benefits of the digital transformation' (European Commission, 2020c).

1.3   How to read this document

This report proposes a framework for the adoption of APIs in government environments. It first gives an overall vision of the framework by illustrating the motivation behind the creation of the framework, the methodology adopted to build it, its structure, how to self-assess its adoption and how it has been validated and used in a piloting activity conducted with Regione Lombardia (Italy). Then, it presents the description, importance of implementation and further literature on each of the 12 proposals forming the framework. Finally, it gives some conclusive considerations. A glossary, the full research methodology used to create the framework and the description of the metrics illustrated in section 3 are set out in the annexes.

As stated above, the goal of this report is to identify best practices for the adoption of government APIs. The literature review collected global best practices. These best practices were then organised into thematic categories. A SWOT and gap analysis were conducted to identify advantages and shortcomings observed in the literature (see Annex 2 for a detailed description of the methodology). Best practices were then organised into a framework model to ensure that government API adoption would use them while also addressing the gaps and shortcomings of the literature review. Twelve proposals have been created within the framework to align it with three application levels of government action (strategic, tactical and operational) and four essential pillars or aspects (policy supports, platforms and ecosystems, people, and processes).

This document is intended for a variety of audiences. Specific sections of this report will be more informative for some readers than others. Intended audiences include:

— **Policy developers, strategy leaders and decision-makers:** These readers will need to understand the context in which government APIs need to be adopted. They will be interested in the vision and opportunity APIs provide, the problems they seek to solve, and how APIs can support their strategy work. This API framework is not intended as a replacement for European Union institutions or Member State policy and strategy. Policy readers will be interested in understanding how APIs are a policy-enabling technology and will be interested in understanding the example implementations of this framework. It is recommended that these readers review section 1, section 2.2 (which explains the framework overall), and section 3.1 (which discusses how policy and strategy work would be supported by implementation of this API framework).

— **Digital government leaders:** These readers will need to understand how an API framework can be used as the backbone infrastructure for digital government efforts. They will need to read all of Part A. They will need to be able to implement proposals 1-4 of the framework and understand who they will partner with to implement proposals 5-8. They will need to be able to understand how the framework works as a cohesive approach and be able to assess their own current digital government programme against their API maturity by using the self-assessment checklists described for each proposal in section 3.

— **IT leaders and digital government architects:** These readers will need to understand the infrastructure components of the API framework. Ideally, they would review this document in partnership with a digital government lead. These readers will be most interested in proposal 3, and proposals 5-12 as each of these proposals includes considerations that will need to be considered when building infrastructure to support this framework.

— **Directorate-general and departmental heads:** Across Europe and in governments of all levels within Member States, each domain area of expertise (each department, for example) will no doubt have their digital government goals. This may include strategy tasks that involve managing data, exposing digital services, creating efficiencies by using digital processes, and so forth. These readers are encouraged to read the overall context, especially the opportunity and vision outlined in section 1.2, and the framework overview in section 2.2. As leaders with responsibility for allocating and managing resources, they will be most interested in proposals 5-8 and will need to ensure that team leaders are able to implement proposals 9-12. They will work with digital government leads to align their departmental work with the opportunities and groundwork that digital leads will do when implementing proposals 1-4. They may use the maturity self-assessment checklists for relevant proposals outlined in section 3.

— **API product managers, API developers, and others responsible for API activities within government:** Public service project members who are responsible for implementing API activities will be interested in the opportunity and vision outlined in section 1.2. They may review section 2.2 to understand the overall framework model and will be particularly interested in proposals 9-12, depending on their organisational role. Product and project managers will also be interested in proposal 8. Technical team members will be interested in proposal 6. All implementation teams will need to be able to refer to how their work generates strategic value and reflects the core principles and platform vision of a government, as outlined in proposals 1-4. A digital government lead or departmental lead may provide guidance on these proposals relating to implementation activities. Implementers will also want to work with their managers to review the relevant self-assessment checklists provided for each proposal in section 3.

— **External stakeholders including non-profit organisations ('non-profits'), community groups, research institutions, and private industry:** External stakeholders will be interested in understanding how APIs will help them partner with governments. They will be interested in the opportunity and vision described in section 1.2, and the overview of the framework in section 2.2. They may be interested in understanding how they can participate alongside governments by reading proposals 2, 3, and 6, in particular.

— **Decision-makers, researchers, and due diligence leads:** Those responsible for ensuring that this framework is of value and for assessing whether this framework should be adopted by an individual government may be particularly interested in Annex 2 of this report. It describes the project methodology and analysis in detail and can help readers determine whether the methodology was robust and sound.

2   An API framework for governments

The purpose of this section is to describe the structure and the main characteristics of a 'basic digital government API EU framework' (henceforth 'API framework' or 'framework'). The framework aims to help governments reorient towards a more coordinated API approach across all of their operations over time. The need for a framework came from our analysis of the existing literature on the adoption of APIs in governments. The analysis, detailed in the final APIs4DGov study report ([1]), shows that some governments in the European Union have already a whole-of-government digital infrastructure, some others have partially implemented it for selected public services and some others are in a design phase. For this reason, this framework and the related assessment tool, do not have to be intended as a set of rigid set of 'recommendations' to be sequentially applied. Instead, they must be adopted in a flexible way, supporting governments to identify the aspects they need to improve and concentrate on these.

2.1   Framework description

The framework has been created by using the robust methodology depicted in Figure 1 and detailed in Annex 2. The methodology advanced, from a literature review stage, to distil best practices and then organise them into a framework. This was then discussed with government stakeholders at three workshops, with the project advisory board, and via an online survey. Moreover, a pilot project was conducted in partnership with the government of the Lombardia region, Italy, to validate the framework in its initial phase. The pilot tested and refined the framework on a concrete case. An online self-assessment tool, to measure maturity towards implementing various framework components, has been created.

Figure 1. Our overall methodology to define an evidence-based API framework for digital government
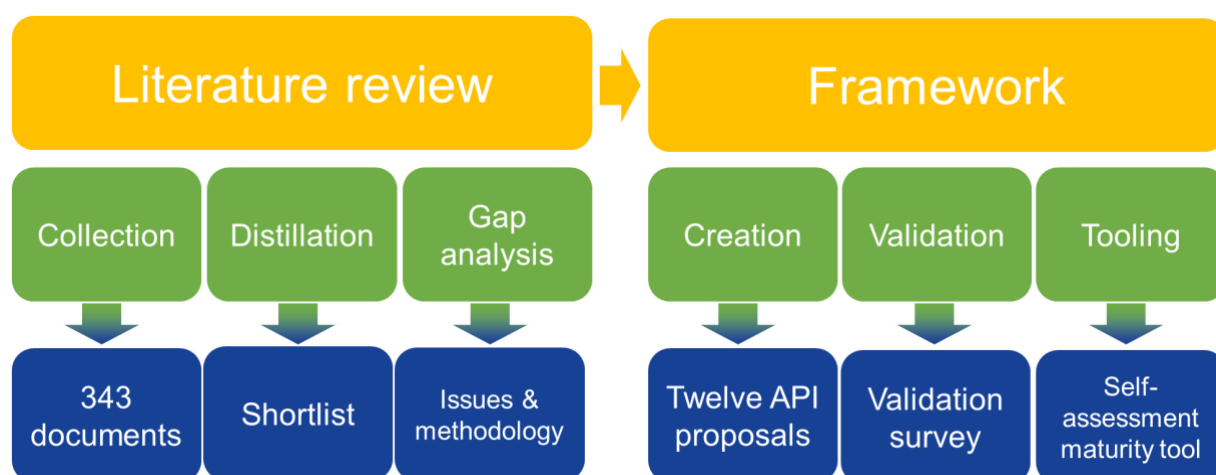
Source: JRC, own elaboration.

The framework includes the main findings from a comprehensive literature review. In total, 343 documents that suggested best practices for government APIs were reviewed, including 63 specific government guidelines and strategies on APIs. Best practices were then collated and gaps in the availability of evidence identified. A draft framework was developed. This framework structures recommended best practices in a cohesive and coordinated way.

From a deep analysis of the best practices documentation we have found that the majority of them are mostly related to operational-level concerns. That is, there is a fairly clear understanding of industry best practices that can be utilised to design, develop and publish government APIs, from a technical perspective. The challenge at the European and Member State level is that APIs are rarely mentioned in strategy and overarching policy documents. While detailed mention may not be warranted, some reference to APIs as a technology enabler which should be used to achieve policy goals would often be useful. To date, this has created some confusion and additional complexity, as alternative approaches continue to be pursued.

([1]) Ongoing publication.

Looking at the private sector, it is worth reflecting on the experiences of industry when use of APIs began to mature. After single-use case adoption of APIs, private industry found that as more APIs were introduced in an ad hoc manner, they created additional complexity. Governments are now facing a similar experience when implementing APIs. Private industry has shown that to be used effectively, APIs require implementation that can ensure they maintain alignment with broader business goals.

It is also difficult to just rely on private industry practice when designing a framework for government API adoption. For example, while private industry is often driven by a profit motive, governments must create social value and provide services to all citizens. Also, private industry companies can focus on relationships that will benefit them the most, governments must focus on fostering economic development and creating level playing fields for all business entities and society. Moreover, private industry businesses tend to focus on the role of delivering products and services to the marketplace, governments have to balance multi-faceted roles that include provider, consumer, facilitator and regulator. Given these unique challenges, we propose an API framework that:

— harnesses the benefits of APIs for digital government;

— reduces the risks of generating complexity through ad hoc API creation;

— facilitates EU cross-national interoperability of data and digital services;

— prepares for API-enabled infrastructure and processes to support artificial intelligence and other emerging technologies; and

— reflects on governments' broader functions and unique roles.

The framework consists of three levels relevant to government action, four aspects (henceforth 'pillars') that reflect the key components of how government operates in a digital context and 12 proposals that aim to guide API-related activities. The 12 proposals have been initially validated within the study with government stakeholders at three workshops, with the study advisory board, and via an online survey. Moreover, a pilot project was conducted in partnership with the government of the Lombardia region, Italy, to further validate the framework in its initial phase. The pilot project tested and refined the framework on a concrete case.

For each proposal, we have created a self-assessment checklist to measure the maturity towards its implementation. All together these checklists represent the 'maturity self-assessment tool' of the framework.

2.2   Framework structure

The framework comprises three levels of action (Owyang, 2013): **strategic** (policy support), **tactical** (such as by a department where resource allocation decisions are being made), and at an **operational** (when APIs are being implemented). For each level, four pillars have been considered. The pillars reflect the capabilities available to governments to carry out action. The four pillars are:

— **Policy support:** Governments set policies and legislation to guide all actions across their operations. APIs are an enabling technology and approach that can help governments achieve their policy goals. This pillar describes how APIs should support policy goals.

— **Platform and ecosystems:** APIs enable platform models and ecosystem networks to develop. This pillar describes the core platform and ecosystem components that need to be in place to make government APIs effective.

— **People:** APIs require new or the update of organisational and team structures within government and new skills amongst the public service and other stakeholders. This pillar describes how people should be organised and supported to manage API activities.

— **Processes:** Best practice processes are available to design, implement and manage APIs. This pillar describes the processes that can ensure high-quality, effective and useful APIs.

Regarding the three levels of actions, governments, representative bodies, and policymakers need to act at **strategic** level that identifies clear broad goals and the vision to advance society and community. This strategic work can be done before APIs are created, or while current API activities continue. It has to be clarified that this API framework can only support policy development. At a whole-of-government (or strategic) level, those responsible for implementing digital government strategies must understand the dimensions they operate in and

where APIs may add value. This will require that they know overarching policy goals, identify the decision-makers' vision for a platform approach, and are aware of the core principles that guide their government's work.

The related four proposals (one for each pillar) describe an ideal scenario where a whole-of-government approach is taken, even if, actually, much of this work is not yet done by the governments at international, national, regional, or city levels. That's why there is a need for the following foundational elements to be in place. Without the following foundational elements in place, governments could create ad hoc APIs that will eventually generate complexity, reduce interoperability, and reinforce existing silos. At an API strategic level, governments need to:

— **align APIs with policy goals**;

— **define the government platform vision**;

— **create governance structures**;

— **form guiding principles for API processes**.

Once there is an understanding of API as enabler that facilitates the achievement of government policy goals, the related four proposals (one for each pillar) drive governments towards a set actionable targets and allocate resources. This work needs to be done by each department and by any cross-government digital government body that may exist. At an API **tactical** level, governments need to:

— **design metrics and prioritise APIs**;

— **harmonise platform and ecosystems assets**;

— **establish cross-competency teams**;

— **follow an API product approach**.

With policy alignment and departmental resources allocated, governments can work on the technical and day-to-day operational elements of adopting and managing APIs. This work needs to be done by teams working within a department, within department sub-agencies, and within a central IT structure. At an **operational** level, governments need to:

— **measure policy impacts of APIs**;

— **build API platform components**;

— **appoint API product manager(s) and teams**;

— **adopt an API lifecycle approach**.

The proposed API framework is thus made up of 12 proposals. Table 1 illustrates the list of proposals of the framework and in the schema of pillars and levels. The elements of the list are numbered, but the sequence of numbers does not imply a rigid sequence of actions, and it is used as an internal (to this report) enumeration. Ideally, strategic actions should guide the tactical ones and, in turn, the operational activities. But, as many situations start within an ongoing digital transformation environment, bottom-up or, more commonly, mixed processes could occur. At each level, action (see also the 'maturity checklist' of each proposal for a series of concrete actions to consider) is needed to ensure APIs align with the four pillars. Workshop activities and survey validation of draft proposals with stakeholders found that government structures are often unique or specific to the local context, so proposals are kept as generic as possible and will need to be considered within the local context. Also in this case, even if it is suggested to consider all of them, governments can select the pillars that better fit their case and the actions to implement each of them could happen in parallel.

Table 1. API framework schema

	Policy	Platform and ecosystems	People	Processes
API strategy	1. Align APIs with policy goals	2. Define the government platform vision	3. Create governance structures	4. Form guiding principles for API processes
API tactics	5. Design metrics and prioritise APIs	6. Harmonise platform and ecosystems assets	7. Establish cross-competency teams	8. Follow an API product approach
API operations	9. Measure policy impacts of APIs	10. Build platform components	11. Appoint API product manager(s) and teams	12. Adopt an API lifecycle approach

Source: JRC, own elaboration.

It is also important to acknowledge that governments are already progressing with a range of API-related activities. It is not pragmatic to imagine that this work can be paused and restarted now that these best practices have been organised into this model. A series of maturity checklists have been developed, half of which have been piloted with a regional government. These checklists assist governments to continue with their current efforts while also reorienting foundational approaches so as to build a more cohesive way forward. Checklists are given at the end of each proposal description.

There are many tasks that need to be conducted to create the cohesive approach to APIs described in these API framework proposals. It is therefore not possible to introduce APIs all at once across all of government. Individual departments or agencies will need to identify which API activities are a priority. Collaboration across them will also need to occur to identify common platform needs amongst all of them that can be budgeted and created collaboratively. Once priorities are set at the whole-of-government level, departments or agencies can allocate resources to adopt API activities or share resources to collaborate across departments on common elements.

2.3   Framework adoption

Figure 2 illustrates a possible workflow for the implementation of this framework. The workflow includes the following steps:

1. **Understand the framework**: This report should be read to understand why and how the framework was generated, its importance, its structure and the description of each of the 12 proposals that form the framework.

2. **Consult additional documents**: In the guideline and for each proposal, a list of additional best practices documents could also be consulted. The entire list of documents is also available as open data at the JRC data catalogue (Boyd and Vaccari, 2020).

3. **Self-assess the adoption of the framework**: the maturity of the adoption of the framework should be self-assessed by following the checklists illustrated in section 3. This step can also be performed online by using the tool illustrated in section 3.1 (Boyd et al., 2020).

4. **Improve the framework**: Optionally, a feedback on the proposals and the framework could be given to contribute to continuously improve the framework.

5. **Change management**: Based on the results of the self-assessment, a gap analysis should be performed and the related organisational change management process should be put in place.

6. **Measure the impact**: While adopting the framework, the impact of the change management process should be measured.

The process could be periodically repeated to refine and review additional changes required for a complete adoption of APIs in the organisation.

Figure 2. Adoption workflow
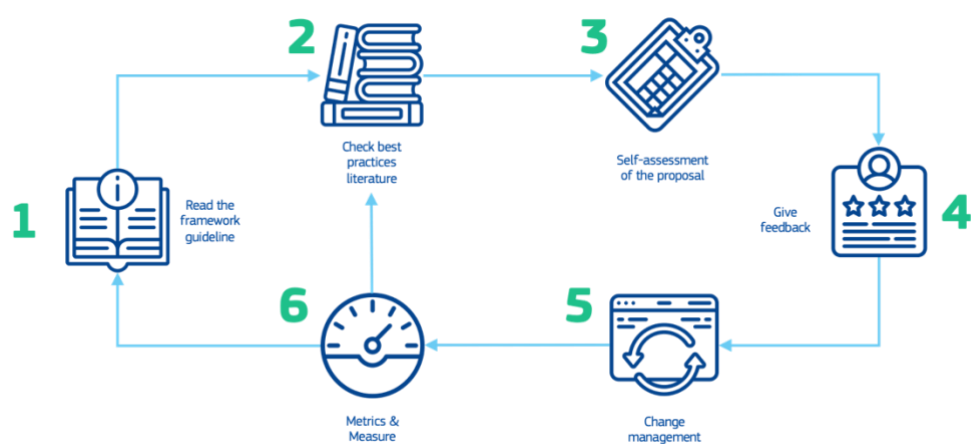
Source: JRC, own elaboration.

3   Framework proposals

The goal of this section is to describe in detail the 12 proposals of the API framework and the structure of the API framework self-assessment tool.

For each proposal we provide an overview box with a brief description of the proposal, the application level and pillar relevant to the proposal (as illustrated in Table 1), and the strength of the evidence that was used to analyse and create the proposal. Following this overview, information on the proposal is divided into the following sub-headings:

— **Importance:** This section explains why each proposal is a necessary element of a cohesive framework. It aims to give inspiration and clarity on why each proposal is necessary when orienting towards a cohesive, coordinated whole-of-government approach to APIs.

— **Implementation:** This section provides a brief overview of how each proposal would work in government settings and how it could be implemented by a government. It draws on the evidence from successful implementations, analysed from the literature and from discussions with key informants and workshop participants. Implementation consideration also includes a list of potential metrics to measure the success of the implementation of each proposal. Output, outcome and impact indicators are given in the table (Annex 3 presents how metrics were designed). For each proposal a checklist has been prepared. All together, these 12 checklists represent the self-assessment maturity tool illustrated in section 3.1.

— **Supporting evidence literature:** This section lists some key literature, with a focus on resources that describe clear tools, templates and processes that governments can follow to implement the proposal. These key resources also include a list of best practices examples, mainly from the European Union governments, that describe current government action linked to each proposal.

3.1   Self-assessment maturity tool

The 12 proposals of the framework are intended to support governments continue and extend their current API activities in a cohesive and structured manner. The framework seeks to assist governments align to a broader policy context, introduce metrics that measure the value and impact of APIs, and make use of best practices at all levels of government work (from policy and strategy, to tactical decisions, to individual API implementations). Reorienting existing government work to make use of the proposed API framework raises two key questions:

— How does a government department build on their own API-initiating efforts while also moving towards adopting government-wide best practices and a more cohesive model that aligns with whole of government and with local, national and international agendas?

— How does a government continue its API activities but also move towards a more structured model that avoids duplication and fosters collaboration, reuse, interoperability and industry innovation?

To give an answer to these questions, within the study, we created a self-assessment maturity tool. **The tool consists of 12 checklists** (one for each proposal) which can be used by a government to measure the level of the adoption of the proposals. The checklists are intended for the digital transformation leaders that contributed to the digital agenda of governments. This/these leader(s) may choose to complete the checklists of the tool with the cross-departmental collaborative body champion or other members of their whole-of-government management team.

The tool lets governments track their level of maturity against the API framework and to identify next actions to address gaps. Maturity models are used by governments in the European Union and around the world to help guide a reorientation process towards new paradigms for government operations. In designing and developing this maturity tool, we have considered three of them, namely: (i) the open data maturity model, proposed by the European Commission; (ii) the Digimat – eGovernment Maturity Assessment (CITADEL H2020 project, 2018), proposed by the CITADEL H2020 project; and (iii) the South Australian Government's Digital Maturity Assessment Tool (Government of south Australia, 2019). These models aim to help governments assess their progress in transforming their key digital capabilities.

These three maturity models each propose a set of dimensions by which maturity can be measured. The dimensions that have been used to structure each checklist include:

— **Organisational infrastructures:** All of the enabling environment that would make implementation of each API framework proposal possible, including governance structures, organisational culture, policy alignment, legal frameworks and IT infrastructures.

— **Organisational leadership:** The management and team that is responsible for acting to implement each API framework proposal.

— **Resource allocation:** The financial, personnel and time resources that are allocated and made available to implement each API framework proposal.

— **Skills (both technical and policy-oriented):** The policy, cultural, programme management and technical capabilities needed by all stakeholders to implement each API framework proposal.

— **Metrics:** The processes available to measure progress, impact and outcomes towards achieving the goals and outputs described in each API framework proposal.

These dimensions map well to the above three maturity models, as shown in Table 2.

Table 2. Dimensions of the API framework self-assessment maturity tool compared with three maturity models.

Maturity dimension used in API framework assessment	Dimensions described in the open data maturity model	Dimensions described in the Digimat model	Dimensions described in the SA Digital Maturity Tool
Organisational infrastructures	Policy, Portal	Organisational, Legal	Governance and leadership
Organisational leadership		People	People and culture
Resource allocation			Capacity and capability
Skills (policy and technical)	Portal, Quality	Technology, People, Legal	Capacity and capability
Metrics	Impact	Legal	Innovation, Technology

Source: JRC, own elaboration.

Next sections illustrate the maturity checklists for each proposal. An online version of the self-assessment maturity tool with all the checklists is also available (Boyd et al., 2020)**.**

3.2   Proposal 1: Align APIs with policy goals

Box 1. Summary of proposal 1	
Description:	Align API adoption to key government policies, strategies and overall plans by considering whether APIs will help achieve the stated policy goals.
Application level:	Strategic
Pillar:	Policy support
Strength of evidence:	Private industry learnt that a use case approach to APIs leads to complexity and duplication. Private industry found that cohesive action required an API-first approach to be supported by senior management and decision-makers. Plans need to consider if management goals, that implement policy goals, should be supported by introducing APIs. In this case, APIs must be aligned to policy goals. Several governments are now moving towards this model, but it is a relatively new approach.

3.2.1   Importance

APIs must serve a purpose and solve problems. Governments already have well-established policy and strategy decision-making processes. As an enabling technology particularly suited to the digital government model, APIs can help governments achieve their policy goals more effectively and efficiently.

An API-first approach is one where an organisation reviews its strategic plans and seeks to identify whether APIs can be used to help achieve the intended organisation goals. That is, an API-first is an approach in which the agency uses APIs as a principal means to pursue its objectives and engage with their stakeholders from the design phase (Lane, 2020; Wilde, 2019).

In private industry, companies are encouraged to 'prioritise API development based on the business's strategy, business and modernisation impact, and ability to execute' (Iyengar et al., 2019). A similar approach can be taken in the government context.

3.2.2   Implementation

The implementation of this first proposal requires that a digital government lead (perhaps partnering with an IT lead) needs to analyse and understand the local policy context and align the API adoption to it. For each documented government policy, a digital government lead or whole-of-government digital coordinating body should consider whether APIs are the best method to support achieving those goals. This may involve:

— reviewing government policies to identify where APIs could support implementation;

— identifying which stakeholders are involved and who is responsible for policy actions;

— understanding the key performance indicators (KPIs) to be achieved (that is, the value to be created);

— mapping the timelines for actions.

Once the policy goals that can be achieved through APIs have been identified, an impact assessment can be carried out to evaluate the costs and benefits of API adoption. For example, existing integrations between government systems may exist to support some government policy action. These may be cumbersome for parties to integrate across governments or between Member States, or between governments and external stakeholders. If proposing that APIs be used to create new integrations, the cost–benefit of relying on existing systems versus the investment in building new APIs needs to be considered. In some instances, key informants suggested that existing approaches may be fit for purpose, and that modernisation via building API infrastructures would not generate the necessary return on investment.

In other cases, prioritising APIs to deliver on policy goals may inadvertently widen a digital divide, especially if intended end users of services have limited access to digital technologies (Negreiro, 2015). There is also evidence that simply moving existing data relationships to API integrations could inadvertently support first-mover advantage (Choudary, 2019) and create additional barriers to SME market entry through reinforcing an imbalance of power. The Open Data Institute's Data Ethics Canvas suggests that digital government teams (Broad et al., 2017):

— 'Focus on the people and communities affected, ways in which they might be affected and steps to mitigate impact;

— Encourage discussion and critical thinking, enabling identification of potential areas of risk and evaluate impacts in context;

— Consider that one type of API and data activity can have lots of outcomes (and potential consequences), depending on the context within which the activity takes place, its purpose and the organisation involved'.

While implementing the adoption of this proposal, it is also useful to assess the impact of it by using different metrics. Table 3 suggests some potential metrics to measure its success.

Table 3. Potential metrics to measure success of proposal 1

Type of metric	Metric
Possible output indicators	A list of current government policy goals and strategies mapped to whether APIs could assist in achieving those goals
	Stakeholder maps and contact directories of policy action leaders across government
	Awareness of KPIs and timelines for policy activities that could be related to APIs
	A proportionate impact assessment process is undertaken for measuring the potential impacts of APIs against key government policy goals (i.e. an impact assessment is warranted as it is expected that the technology will have significant impacts on the intended policy goals)
Possible outcome indicators	Reduced duplication and increased efficiency in managing multiple policy streams of government using digital technologies
Possible impact indicators	Societal benefits of the use of APIs are achieved while reducing the potential for negative impacts from APIs/platform models
	Easier data sharing (within permission constraints), more partnership and collaborative activity and faster product development to achieve policy goals
	Increase of levels of trust, civic engagement, local economic development and sustainable resource use across society due to the use of APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 4 illustrates a possible checklist to perform the evaluation.

Table 4. Maturity checklist of proposal 1

Maturity dimension	Question
Organisational infrastructures	1. Is there a vision/strategic plan in place with clear government goals?
	2. Is there an organisational map that describes any cross-departmental collaborative body/bodies at a high level with oversight of API activities?
Organisational leadership	3. Has this cross-departmental collaborative body reviewed all government strategic plans and policies and identified opportunities where APIs could play a role?
	4. Is there a champion(s) with responsibility for steering an API strategy within a cross-departmental collaborative body?
	5. Has this champion(s) identified internal and external stakeholders relevant to the strategic plans and priorities where APIs could play a role?
Resource allocation	6. Is there government-wide commitment to working across departments to achieve goals through sharing resources and reducing duplication?
	7. Are there mechanisms to iterate and continually improve API activities and progress
Skills	8. Are policy stakeholders with responsibility for key goals informed where APIs could play a role in helping achieve outcomes for them?
	9. Is the champion(s) in contact with IT leaders across whole of government? Or, is the champion(s) in contact with IT leadership within each department with relevant policy goals?
Metrics	10. Is there an impact assessment instrument available to measure the potential positive and negative impacts that could be generated if APIs are used as an enabling technology for each of the identified policy goals?

Source: JRC, own elaboration.

3.2.3   Supporting evidence literature

Additional resources to assist with implementing proposal 1 include:

— **'Strengthening Digital Government'** (OECD, 2019a): Recommends to 'Develop a digital government strategy, complemented by a plan of action and an impact assessment instrument. The strategy should indicate expected outputs, outcomes and impacts, and should be formulated with the involvement of public sector organisations across all levels of government and consulting external stakeholders.' This document provides governments with further evidence of the importance of implementing this API framework proposal.

— **European Commission Better Regulation toolbox tool 13,** 'How to undertake a proportionate impact assessment' (European Commission, 2017a): For governments wanting to commence an API-focused impact assessment, Tool 13 proposes a methodology that could be adapted to measure whether using APIs to help implement policy goals would have any negative impacts. Further discussion on the potential negative societal, business and individual impacts of APIs are described in Volume 2 of this research and should be reviewed when considering how to assess the potential impacts of a government API approach.

— **Data Ethics Canvas:** This white paper mainly deals with the data sharing and very little with APIs. However, it includes a data ethics canvas framework that can be used as a foundation when considering the implications of opening data as assets, also via API. For example, 'ethical issues may arise where the terms of service associated with physical data infrastructure and the data they collect (e.g. via smart meters, field sensors and smart cars) prevent people in practice from switching providers and accessing historical data about their behaviour, collected on equipment that they own, outside of that infrastructure' (Broad et al., 2017).

— **The Netherlands government** has identified a number of challenges that face government in the move towards digital services (Geonovum, 2019). One of the biggest problems they identified was that complexity across their digital systems has increased and was putting citizen data at risk, increasing costs through duplication and errors, creating barriers for citizens and business, and reinforcing reliance on existing suppliers. The Netherlands government adopted an API approach to help simplify digital systems and speed up innovation opportunities. But to do so they first recognised: 'The mission of an organisation determines whether APIs have added value in the ICT processes.' They are directed by national legislation which includes future requirements from the open data directive (European Union,

2019) which will mandate the availability of reusable government data in their revised Reuse of Government Information Act. A communication and policy working group was established to identify current policy drivers which could be supported by APIs and an API-enabled infrastructure. This included a review of existing API activities across government, as well as identifying strategic opportunities to create cross-government collaborative API approaches.

— **Sweden's Geodata strategy** for the years 2016-2020 is driven by the European Union's INSPIRE directive (European Union, 2007). They have created a cross-government collaborative body working with private actors (an ecosystem), and have aligned the strategy with the 17 sustainable development goals. From this, they have identified five key challenges for the geospatial data strategy and note 'All challenges would finally benefit from reliable and well-known API services with clearly stated service level commitments.' Lantmäteriet, the Swedish governing body implementing the geodata strategy, 'expects that developments will take a leap step forward when such APIs with high quality authoritative geodata become generally available for use in public and private sector applications.' (Lantmäteriet, 2017)

— **The Italian government** introduced a Decree that encouraged 'powers of stimulus and coordination, along with providing guidance to public and private entities for the realisation of actions, initiatives and essential works, connected and instrumental to the implementation of the Italian Digital Agenda, also in line with the objectives of the European Digital Agenda'. This Decree led to the creation of a 3-year IT strategy, alongside the adoption of enabling platforms and the development of interoperability rules that are clearly defined and based on APIs to permit systems to communicate with each other (Italian digital agency (AGID), 2018).

— **The French government's** modernisation plan states (French Secretary-General for the Modernisation of the Public Action, 2019):

- 'The state platform facilitates the flow of data between public and private organisations.

- Its architecture framework recommends administrations to open their APIs according to web standards.

- All public actors, regardless of their profile, are expected to participate to the national platform.'

This has driven activity by central government agencies (to create the national identity verification API (Amarelis, 2018)) as well as individual department actions.

— **The Victorian Government's Department of Premier and Cabinet** has implemented an APIfirst approach in which any new digital services and exposed data must be created using APIs. Under their family violence prevention strategy, they had defined clear goals for ensuring swift access for survivors of family violence to be able to access a range of services. They identified that APIs could be used to help people using family violence services to connect faster and more safely. As reducing violence against women was a state-wide policy priority, they also had reporting requirements on KPIs. These datasets were also identified as potential API opportunities (Victorian Government, 2019a).

3.3 Proposal 2: Define the government platform vision

Box 2. Summary of proposal 2	
Description:	Explore and confirm the government's vision for a whole-of-government digital platform. This will assist when building stakeholder relationships and setting API priorities.
Application level:	Strategic
Pillar:	Platforms and ecosystems
Strength of evidence:	Evidence from implementations of digital transformation in government suggests that a lack of clarity on the platform model being adopted by a given government can hamper efforts to build collaborative approaches across government operations and with external stakeholders.

3.3.1 Importance

A clear platform vision is needed to help guide resource allocation decisions and to create appropriate implementation practices. Governments must decide how their digital assets will be shared, who should be part of their ecosystem networks, and what level of private–public community partnerships are desirable.

Governments introducing APIs are embracing platform-based models in which services and data assets are shared internally between departments and can also be exposed securely to external stakeholders. This approach alters the current government model, including current budgeting models and cross-collaboration approaches [2]. In an API-enabled government platform model, governments are producers, consumers and regulators at the same time and consideration of how these roles intersect is an important visioning exercise to undertake before embarking on a whole-of-government API strategy (Koponen, 2018). But without a defined platform model, governments risk simply replicating existing paper-based processes as digital services. This does not address siloed departmental approaches, and reinforces the current market barriers to participation that exist in traditionally organised systems (Margetts and Naumann, 2017; Gartner, 2019; Finnerty, 2018).

Governments can step back from a purely 'digital government' agenda (in which government provides 'digital services'), and consider what a digital platform approach would look like and how it would operate and provide benefits. For example, in Australia, the national Digital Transformation Agency reimagined government services as being automated and evoked at key life transition stages (also known as life events-based actions). These events include birth, marriage, completion of education, and starting a business (Digital Transformation Agency, 2019). The Singapore government has introduced a similar model as part of their API and digital government strategy titled 'Moments of life initiative' (Smart Nation Singapore, 2020). To engage with citizens around life events-based actions in this way requires governments to operate as an internal platform in which various departments are connected together and work in partnership to create the service that is then provided to the citizen.

This new paradigm of joined-up and automated service delivery by government is not imaginable if the starting point for API creation is to simply convert the paper form-based processes into a digital service. Evaluations and reflections by policy leaders involved in digital government transformation agendas have noted that the biggest failure has often been that governments have not been 'bold enough' in envisioning new platform models of government (Loosemore, 2018).

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[2]   Collaboration on public services indicates that government pursues collaboration with third parties to deliver added value in public service design and/or public service delivery. Collaboration uses shared resources, taps into the power of mass collaboration on societal issues and can lead to the development of innovative, distributed and collective intelligent solutions. Collaboration is also related to the concept of service-oriented principles of reuse, composition and the modularity of a service. With the addition of new services, new (public) value is proposed to users. This value does not only relate to creating private value for new businesses, but also relates to creating public value, i.e. added value for society.

3.3.2   Implementation

A digital government lead or whole-of-government coordinating body for digital government activities will need to identify the current government digital platform vision. This may involve reviewing vision statements, identifying relevant policy debates where platform approaches are being discussed.

Gartner recommends that digital government and CIO leadership within government 'inspire the organisation's leadership to invest in a platform approach to digital government by showing them the benefits realised by other governments that successfully implemented a digital government technology platform' (Finnerty, 2018). They also suggest building internal support by demonstrating the cost–savings benefits created from platform components such as APIs, which reduce developer time to build new digital services.

By articulating a platform vision for government APIs, new opportunities to use APIs to deliver on this vision emerge naturally (Dastur, 2018). For example, in the Communication about the 'European Commission Digital Strategy' (European Commission, 2018b), one of the goals is to co-create value with external parties. By acknowledging that this is part of a platform model being adopted, it is easier for strategic implementers to see the role that APIs could play in enabling that co-creation. This vision could inspire new thinking around common data models and identifying priority ecosystems, which, in turn, could trigger discussions around future viable private–public partnership business models.

The platform vision identified in this framework proposal will be used throughout the rest of the framework, most notably in proposals 6 and 10 where the platform vision guides decisions on ecosystem network membership, and IT platform components.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 5 suggests some potential metrics to measure its success.

Table 5. Potential metrics to measure success of proposal 2

Type of metric	Metric
Possible output indicators	Clear statement of the government's platform vision and or preferred platform model
	Stakeholder maps and contact directories of policy action leaders across government
Possible outcome indicators	Clearer procurement processes and contracting reporting that reflect the platform vision, for example, creation of contract requirements that ensure the availability of data by government suppliers
	Clearer communication processes when working in partnership models to create and deliver digital products and services
	Greater engagement and feedback from businesses and citizens on government actions using digital platforms
Possible impact indicators	Greater citizen trust, participation and more local economic development from clearer partnership activities that reflect the government's platform vision

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 6 illustrates a possible checklist to perform the evaluation.

Table 6. Maturity checklist of proposal 2

Maturity dimension	Question
Organisational infrastructures	1. Is there a vision/strategic plan in place with clear government goals?
	2. Has the government envisioned the IT infrastructure that could be introduced to support this platform vision?
	3. Is there internal agreement on how to harness various stakeholder roles in an API-enabled, digital environment?
Organisational leadership	4. Is there agreement on the level of engagement and partnership government decision-makers will have with external stakeholders?
Resource allocation	5. Has the government allocated resources (budget and staff) to support the work of various stakeholders (i) internally, (ii) between departments and, (iii) where identified as desirable, with external stakeholders?
	6. Are common data and service sharing agreements considered by stakeholders?
Skills	7. Are policy stakeholders with responsibility for key goals well informed as to where APIs could play a role in helping achieve outcomes by using a platform approach?
	8. Are government leaders acting in ecosystem facilitation, external collaboration, and managing data sharing agreements with external contractors and in B2G relationships?
Metrics	9. Can the government measure the levels of engagement in digital ecosystems and identify groups that are under-represented from participating?

Source: JRC, own elaboration.

3.3.3 Supporting evidence literature

Key resources that can be used to assist with implementing proposal 2 include the following:

— The **OECD's Strengthening Digital Government guidelines** recommend including a recognition of government-as-a-platform as part of digital government agenda (OECD, 2019a).

— **ATOS report: Realising the promise of Government-as-a-Platform** discusses the value and benefits of moving to a government-as-a-platform model and describes a digital transformation process to aid reorientation efforts. Also, in the report, the API platforms were identified as an early adoption high impact technology that 'allow offerings to be distributed and serviced across third parties. Governments players should put API platforms at the heart of their digital strategy to attract private, NGO and other public ecosystem partners' (Atos, 2018).

— The **'Vision for public services'** document of DG CNECT identified that collaboration with citizens and users plays an increasing role in the transformation of public services towards new forms of production and delivery and that at design level GaaPs is a mechanisms of an open and collaborative government for a possible future for public services (European Commission, 2013).

— The **European Interoperability Framework** recommends articulating a conceptual model that can then be used to guide governments at all levels in their efforts to 'identify, negotiate and agree on a common approach to interconnecting service components'. Without a shared conceptual model, the European Interoperability Framework suggests that it is more difficult to guide the planning, development, operation and maintenance of integrated public services by Member States (European Commission, 2017b). Moreover, the **2019 EIF workshop on 'Implementation and governance models'** reported that: 'A repeated emphasis during the discussions on organisational interoperability was on "why" the integrated public service project is being implemented. Without a common vision on this, it will not be possible to align processes and activities. This is particularly important when trying to align across completely different organisations or administrations – where there can be cultural differences and a lack of trust which are challenging to overcome' (Pinzon et al., 2019).

— The **New Zealand Government's initial API Standards Guidelines** in 2016 first raised some of the conceptual questions governments would face in moving towards an API-enabled platform model. The document highlights the conceptual thinking a government can undertake to define its platform vision and in particular that agencies need to expose information and services to each other and to external stakeholders (protecting at the same time the privacy of the information), the need for a customer-centric service delivery and the fact that government is also 'actively encouraging third parties to use

government services to create value added services for their own customers: 'Opening up' agency services to third parties will encourage commercial organisations and NGOs to act as intermediaries for government services, and has the potential to dramatically improve interactions with government' (Government of New Zealand, 2016).

— The **French Government's Modernisation Secretariat-General** connects whole-of-government policy goals with a clear, yet simple vision of its platform model. It explains that a platform and ecosystem approach will allow government to:

● simplify the creation of digital services that participate in public policies;

● give users more options for accessing public services;

● secure the exchange of confidential data between the actors of the ecosystem.

In summary it declares the state's platform approach is 'in the service of the general interest and is a lever of sovereignty' (French Secretary-General for the Modernisation of the Public Action, 2020).

3.4 Proposal 3: Create governance structures

Box 3. Summary of proposal 3	
Description:	Establish governance structures (₃) to ensure that APIs align with policy and ecosystem priority use cases, address security threats and risks, review equity impacts, and use standards and agreed style guidelines.
Application level:	Strategic
Pillar:	Policy support
Strength of evidence:	Evidence shows that governments have experience in building effective data governance using information management frameworks. Some governments are now applying those principles to API governance. While these processes are emerging, there is limited documented evidence describing effective operationalisation of governance processes within government. Industry is also at a similar stage of early maturity, with many enterprises still testing their introduction of governance processes.

3.4.1 Why this proposal is important

Governance structures perform an integration of public services, ensure a holistic governance of interoperability activities across administrative levels and sectors, identify and select standards and specifications and participate in standardisation work relevant to the needs of the organisation. They also address and manage risks, establish common rules to address unexpected issues and ensure adherence to wider government policy principles.

The **EIF 'integrated public service governance'** layer requires, to ensure interoperability, among other things, 'organisational structures and roles and responsibilities for the delivery and operation of public services, service level agreements, establishment and management of interoperability agreements, change management procedures, and plans for business continuity and data quality'. Services should be governed to ensure: integration, seamless execution, reuse of services and data, and development of new services. Organisations involved in European public service provision should make formal arrangements for cooperation through interoperability agreements. Setting up and managing these agreements is part of public service governance (European Commission, 2017b).

3.4.2 Implementation

Governance models are emerging to oversee government API activities or to manage cross-agency digital transformation work. There is limited discussion on how to co-opt existing structures to enable extension of governance capabilities to encompass API activities. There are few tested models that have been designed and implemented on a consistent basis. There is a lack of available evidence describing the operational processes, including enforcement rights of governance structures, to oversee new API development.

There are several factors that will influence the establishment of appropriate governance structures, including (OECD, 2019a):

— Skill sets and understanding of APIs amongst potential governance committee members;

— The availability of resources such as risk assessments and API style guides to assist oversight;

— Government visions of a platform model, as this may influence the degree to which a governance committee is a facilitator that encourages action, or a prescriptive regulator that approves or rejects the API-focused activities of various government departments and teams. While both models are valid, the

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(₃) An emerging best practice in several governments is the concept of introducing governance structures to:
  — align APIs with wider strategies including an information management and interoperability agenda,
  — assess operational risks, legal risks and compliance with existing regulations, and
  — ensure internally built APIs adhere to established design guidelines and standards.
  Much of this work is in its infancy. Structures from private industry are also relatively new, as many companies are themselves grappling with the appropriate balance between setting prescriptive standards for API design and allowing individual lines of business to create APIs that meet their specific use case needs. An essential best practice API framework component is a governance structure that defines the appropriate level of enforcement required to maintain alignment across government policies and API-based activities.

government's platform vision will guide the type of governance structure that is best suited to the government's decision-making culture.

Governance structures require multiple levels of oversight:

— At the **European Union level,** there is a need for guidance on API design and lifecycle management standards, this would have both a business and technical focus, and would act as a centre of excellence, proposing best practices for design and product management of APIs. A centre of excellence model establishes whole-of-government, standardised best practices and creates resources to help European Union institutions and governments of the Member States at various levels to apply these best practices when adopting APIs.

— At **European Union institution, Member State, regional and city government levels,** there is the need for whole-of-government committees to oversee interoperability within and across borders, API-enabled infrastructure decisions, API design principles, and product management strategies. The whole-of-government level at each tier could also map the shared capabilities (4) and common datasets and allocate departmental leads for these APIs and registries (5) and common data repositories that should function across the whole of government. Each department would then need its own governance committee to ensure that departmental-level API strategies leverage the whole-of-government architecture, that a minimal set of shared information is being used and that best practices are being followed.

— In **all governance committees,** there will be a requirement to ensure representation from a body that advocates and works with communities and populations at greatest risk of digital exclusion and to assist with monitoring and managing the risks of detrimental impacts if influenced by API adoption.

Another challenge will be to create sufficient governance structures to encourage knowledge-sharing, prevent duplication, and ensure the use of interoperable and standardised methodologies without generating too many additional committees or reallocating project resources to the creation of new governance structures. It may be required to assign the tasks to an existing committee (such as, for example, the eGovernment Action Plan steering board at the EU level (European Commission, 2016a), as long as sufficient expertise and authority are represented.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 7 suggests some potential metrics to measure its success.

Table 7. Potential metrics to measure success of proposal 3

Type of metric	Metric
Possible output indicators	Governance committees with membership across government operations
	Operational guidelines to assist governance structures to manage and enforce decisions
Possible outcome indicators	Reduced costs (including time) due to ease of reuse of API components
	Faster adoption of APIs across government as users who are familiar with one API can now use other APIs in the same way
	Faster product development within and between government departments
Possible impact indicators	Increased economic development as third parties are able to create products and services faster
	More choice for citizens and businesses as more innovation able to be generated
	Greater participation in activities and economy by all societal actors due to reduction in complexity and duplication

Source: JRC, own elaboration.

(4) Multiple government departments often have to perform the same actions during government service delivery, such as to enable application forms to be completed online, to verify a user's identity, or to transact a payment. At present, each government department may build their own web service to enable such processes. Under an API framework model, service capabilities shared across government departments would be built once via API and reused as service components across multiple channels, by multiple departments.

(5) Traditionally, government departments might each maintain their own datasets. To improve the semantic interoperability, government departments should identify key terms, common vocabularies and common data that should be maintained in one place and shared globally. These are then referred to as 'registries', that is, single sources of truth.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 8 illustrates a possible checklist to perform the evaluation.

Table 8. Maturity checklist of proposal 3

Maturity dimension	Question
Organisational infrastructures	1. Is there a structure in place at both whole-of-government and departmental levels that supervises the following aspects?
	— Overall oversight: Decides membership of each governance committee and sets reporting requirements to ensure alignment and consistency across all governance committees within the government's structures and alignment with policy and strategic goals
	— Strategy and interoperability: Oversees digital strategy and API framework implementation (setting priorities, modernising infrastructure, reviewing annually against changing the digital landscape, ensuring alignment with other interoperability and digital transformation agenda)
	— Cybersecurity: Oversees implementation of cybersecurity best practices including policies on identity management and access permissions to data and services and regular monitoring and updating of best practices
	— Risk and operations: Creates technology to support the development and exposure of APIs across government; creates and collaborates on holistic API design standards; reviews new integrations and ensures they comply with these standards and design guidelines; and oversees legal and compliance risk requirements at whole-of-government, departmental, programme and project levels
	— Information management: Oversees data management, data interoperability, data sharing and data protection
	— User needs: Ensures the API framework's roadmap will be able to meet consumer needs in the future, with regular assessments of internal, partner and external stakeholder API consumption and collaboration needs and of co-creation efforts with partners
	2. Is there a structure in place at both whole-of-government and departmental levels that provides oversight of user needs to ensures the API framework's roadmap will be able to meet consumer needs in the future, with regular assessments of internal, partner and external stakeholder API consumption and collaboration needs and of co-creation efforts with partners?
	3. Does each committee have:
	— Reporting structure/oversight structure
	— Membership and attendance list
	— Terms of Reference
	— Standard agenda
	— Regular schedule of meeting dates
	— Agreed set of standard procedures including standards used, internal API style guidelines, accreditation/review process, etc. that can be used to assess new and existing API initiatives
	— Checklists/tools based on procedures for assessing new API initiatives
	— Checklists/tools based on procedures for monitoring existing API initiatives?
	4. Is there an organisational chart or map that shows how all governance committees are related and how decisions are overseen and communicated to whole-of-government leadership?
Organisational leadership	5. Is there an executive-level leader to champion the importance of governance and to ensure the work of governance committees is implemented and monitored?
Resource allocation	6. Are there clear funding mechanisms for governance?
	7. Are there budget and resources available for consultation, training and support of departments and external stakeholders to ensure alignment with governance requirements and to improve overall literacy around APIs?
Skills	8. Do members of the governance committee have a leadership position and advocate for API initiatives?
	9. Collectively, do members of governance committees have skills in: cybersecurity, compliance/regulation/legal risks, risk assessment and management, strategic policy, enterprise architecture and API design, internal API standardisation policies, ecosystem user needs and external stakeholder liaison?
Metrics	10. Does the governance committee regularly monitor and manage risks that have or may emerge from the detrimental impacts of API adoption?

Source: JRC, own elaboration.

3.4.3   Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **European Commission EIF** guidelines gives a set of recommendations to public administrations on how to improve governance of their interoperability activities, establish cross-organisational relationships, streamline processes supporting end-to-end digital services, and ensure that existing and new legislation does not compromise interoperability efforts. It includes four interoperability layers, an integrated public service governance layer and a 'interoperability governance' layer to ensure a holistic governance of interoperability activities across administrative levels and sectors, to identify and select standards and specifications, and that should participate in standardisation works relevant to the needs of the organisation. (European Commission, 2017b).

— The **Communication on a 'European Commission Digital Strategy, a digitally transformed, user-focused and data-driven Commission'** articulates a possible set of governance structures that could be followed when establishing whole-of-government coordination and oversight of government digital transformation and API-related processes (European Commission, 2018b). The European Commission's Digital Strategy proposes governance structures including the following:

  ● Consolidation of IT and Cybersecurity Board to oversee data management, data interoperability, data sharing and data protection as well as oversee digital strategy implementation (setting priorities, modernising infrastructure, reviewing annually against a changing digital landscape).

  ● Information Management Steering Committee to oversee data management.

  ● Governance structures for individual projects and development work should demonstrate that data is at the core of the design process and will be assessed by the IT and Cybersecurity Board.

  ● Governance structures will be established for co-creation development activities.

  ● The Strategy will also utilise the European Commission's CII infrastructure (Comité Informatique Inter-Institutional).

— The **Victorian Government Information Management Governance Guideline** provides useful government guidelines for establishing key roles in a governance structure, sample terms of reference, and outlines key actions required to support and manage governance. For a government considering how to create and manage governance structures, these guidelines are a useful foundational model to adapt to a government's own specific context (Victorian Government, 2017). The Victorian Government of Australia has established a whole-of-government API gateway team that has responsibility for:

  ● creation of technology to support the development and exposure of APIs across government;

  ● creation and collaboration of holistic API design standards;

  ● consultation, training and support to improve overall literacy around APIs and integrations;

  ● engagement and evangelism of APIs and integrations both internally in government and out to partners and the community.

3.5 Proposal 4: Form guiding principles for API processes

Box 4. Summary of proposal 4	
Description:	Collect together a government's existing principles in digital service delivery, technology selection, data privacy, and cybersecurity. This will be useful to have at hand when allocating resources or designing API activities and implementations.
Application level:	Strategic
Pillar:	Processes
Strength of evidence:	Governments are fairly advanced at documenting core principles that guide their operations. Strong evidence exists to demonstrate the value in ensuring that all stakeholders are able to reflect on and design activities that align with organisational principles.

3.5.1 Why this proposal is important

A set of core principles (6) help guide government actions when implementing digital government models. Principles help governments maintain accountability and transparency by providing all stakeholders with a clear means of assessing the motives and commitment to government action. Governments can review their core principles and ensure that they are understood by the teams responsible for overseeing digital government, cybersecurity, interoperability, and API-focused activities across all of government.

3.5.2 Implementation

Digital government leads can review organisational core principles and ensure that they are understood by the teams responsible for overseeing digital government, interoperability, and API-focused activities at the whole-of-government and department levels. These principles would be shared amongst members of any governance structure to ensure that they are incorporated into oversight processes. Principles should act as a foundational component when deciding on tactical and operational actions, including when selecting what API tooling, software and technology to adopt.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 9 suggests some potential metrics to measure its success.

Table 9. Potential metrics to measure success of proposal 4

Type of metric	Metric
Possible output indicators	Core principles documented and available for anyone to read
	Checklists to ensure that new internal projects and funding of contracts address core principles
Possible outcome indicators	High quality and consistent product and service development within government
	Clarity of contractual arrangements with third party suppliers
Possible impact indicators	Greater transparency of government decision-making

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 10 illustrates a possible checklist to perform the evaluation.

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(6) Many governments have documented digital service core principles that reflect their overarching values when moving to a digital government model. These principles are useful to reflect upon when designing API strategies. Core principles help ensure alignment between core government principles and API activities when setting priorities, allocating resources and implementing actions.

Table 10. Maturity checklist of proposal 4

Maturity dimension	Question	
Organisational infrastructures	1.	Has an overarching body that sets IT core principles (see for example, Table 11) for digital government, digital services, cybersecurity, data privacy, and/or technology choices?
Organisational leadership	2.	Is there an ambassador role working across government promoting awareness of principles to departments and stakeholders?
Resource allocation	3.	Are mechanisms in place to review new projects/products/outputs to ensure adherence to principles?
Skills	4.	Are all departments and digital service stakeholders in each department aware of the principles?
	5.	Are there practical user guides and tools available to help product managers and technical leaders to ensure that principles are upheld in design and delivery of API-related activities?
Metrics	6.	Are the principles reflected in metrics collection and reporting?

Source: JRC, own elaboration.

3.5.3   Supporting evidence literature

Table 11 compares several examples of government core principles analysed from international, European and national policy documents. These principles aim to ensure that digital services and digital transformation activities (including the adoption of government APIs) create social value and are delivered in a way that reflects citizen rights.

Table 11. Examples of government and institutional core principles related to APIs.

OECD	European Commission	European Commission	Italy	France
OECD: Recommendations on Digital Government Strategies (OECD, 2014)	*European Union: Tallinn Declaration (Estonian Presidency of the Council of the EU, 2017)*	*European Commission: Interoperability Framework (European Commission, 2017b)*	*Italy: 3-year ICT Plan (Agenzia per l'Italia digitale, 2019)*	*France: Principles guiding modernisation (Government of France (DINSIC/DINUM), 2020)*
Ensure greater transparency, openness and inclusiveness	Digital by default, inclusiveness and accessibility	Subsidiarity and proportionality	Digital by default	Let's play as a team with a mandated captain
Encourage engagement and participation	Once-only principle	Reusability	Once only	Solve a problem rather than build a solution
Create a data-driven culture	Openness and transparency	Inclusion and accessibility	Cloud first	Think big and move small
Address security and privacy issues	Interoperability by default	Administrative simplification	Inclusiveness and accessibility of services	Let's be transparent and realistic about the objectives and stay the course
Secure leadership and political commitment	Trustworthiness and Security	Openness	Territorial inclusiveness	Let's face reality early
Ensure coherent use of digital technologies Establish governance frameworks		Technological neutrality and data portability	Openness and transparency of data and administrative processes	Let's simplify, always
Strengthen international cooperation		Security and privacy	Cross-border by definition	Let's experiment, innovate
Develop clear business cases		Preservation of information	Interoperable by definition	Build with our ecosystem
Reinforce institutional capacities		Transparency	Trust and security	Exploit the full potential of data
Procure digital technologies		User-centricity		
Ensure general and sector-specific legal and regulatory frameworks		Multilingualism		
		Assessment of Effectiveness and Efficiency		

Source: JRC, own elaboration.

3.6 Proposal 5: Design metrics and prioritise APIs

Box 5. Summary of proposal 5	
Description:	In partnership with stakeholders, identify a priority order for the government's API-related activities. Define how success will be measured for each activity area. Ensure that metrics are focused on measuring the value being created, and on monitoring whether any adverse equity impacts are being introduced.
Application level:	Tactical
Pillar:	Policy support
Strength of evidence:	Governments have mature experience in prioritising workloads within limited resources and budgetary constraints. This includes working at whole-of-government and departmental levels on setting priorities. There is limited evidence of governments sharing departmental budgets to reuse digital components or datasets across government. There is a small amount of evidence of governments using metrics to calculate the value that APIs are generating. This is also true for private industry, where the measurement of the value that APIs are creating (apart from monetised APIs) is limited.

3.6.1 Why this proposal is important

In a digital government context or with governments undergoing digital transformation processes, there are often a number of API activities being undertaken at any one time. These are often independent of each other. Taking an API-first approach will also identify opportunities to introduce APIs to support policy goal actions. This will create an extensive list of API activities and opportunities which will need to be prioritised.

To ensure that APIs are achieving policy goals, metrics will also need to be introduced to measure the policy impact of APIs. Metrics need to be defined that will measure if APIs are better enabling policy goals to be achieved, i.e. figures about the connections with external actors (G2B, B2G, G2C); figures on the reduction of the digital divide; figures on the overall efficiency gains of the organisation; and, in the case of platform environments, figures about networking effects.

There is a lack of available metrics for governments to measure the value that their APIs are generating. For example, governments have released real-time traffic, public transport and parking space location APIs. Together, apps built with these APIs could help citizens and tourists to more easily and directly travel around a given location. This could increase reported conviviality and dynamism of an area. It could also reduce traffic congestion and reduce CO_2 emissions. Alternatively, these APIs could help encourage use of rideshare services which could increase traffic congestion, route more traffic through low income areas, and increase CO_2 emissions. While there is some evidence that APIs do help generate both value and harm in this example, this analysis has been done in separate studies (Erhardt et al., 2019; Government of Massachusetts, 2019; Le and Pishva, 2015), each as part of a retrospective, one-off research project. The literature review did not find any documented examples of data on value being regularly collected and analysed by governments.

3.6.2 Implementation

Proposals 5-9 draw on the fact-finding activities of proposals 1-4 to make resource allocation decisions at both a whole-of-government and departmental level.

Cross-government bodies or digital government leads will need to review a stakeholder analysis of current decision-makers and project leaders who are participating in government API activities. The policy analysis of where APIs can help support government goals will also need to be reviewed. Together, these summaries can be discussed by a digital government leadership team to set priorities and work in a cohesive manner across government departments. This would allow the team to identify opportunities to use shared services, create data registries, and reduce duplication and complexity. Once key priorities are agreed, the leadership team can define what success is expected and what value is assumed will be generated from the API activities. This could be cost reductions/efficiencies, greater range of services for citizens and businesses, new government revenue streams, greater citizen trust, more dynamic economic opportunities, reduced environmental burden, and so on.

While implementing the adoption of this proposal, it is also useful to assess the impact of it by using different metrics. Table 12 suggests some potential metrics to measure its success.

Table 12. Potential metrics to measure success of proposal 5

Type of metric	Metric
Possible output indicators	Each department that includes API activities in their strategy indicates what metrics have been adopted to measure these activities
	Shared resource components that have been agreed to be built across government departments to assist individual departments carry out their API activities
Possible outcome indicators	Reduced cost in government digital service delivery with increased use of APIs and API-enabled infrastructures available across government departments
Possible impact indicators	Improved citizen and business engagement with a more interoperable approach to government public service provision

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 13 illustrates a possible checklist to perform the evaluation.

Table 13. Maturity checklist of proposal 5

Maturity dimension	Question	
Organisational infrastructures	1.	Are KPIs identified for each of the policy goals identified in proposal 1 for which it was decided APIs could assist in supporting?
	2.	Are KPIs identified for each of these API activities?
Organisational leadership	3.	Are there clear milestones and timelines in place for each policy goal and related departmental API activity?
Resource allocation	4.	Are resources allocated to conduct measures at a whole-of-government and at departmental levels?
	5.	Are internal use cases for APIs prioritised?
	6.	Are resources in place to ensure that priority API activities are completed in order?
Skills	7.	Do decision-makers and departmental leaders agree on the actions to take and in what priority order?
	8.	Is research being conducted across government to create standardised ways to calculate the value of APIs in contributing to specific goals?
Metrics	9.	Are there mechanisms in place to monitor risks, course-correct, and reorient API activities based on regular metrics reporting and analysis?

Source: JRC, own elaboration.

3.6.3   Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **European Commission's** *Recommendations on a European Electronic Health Record Exchange Format* has prioritised activities to develop the fast health interoperability regulation (FHIR) API standard. This strategy recommends prioritising future work including 'a review of new approaches to interoperability specifications, such as relevant application programming interfaces (APIs)'

— The report about the **'European Interoperability Framework (EIF) Implementation and governance models'** workshop provides some discussion and experience on successful approaches to ensure this type of Departmental alignment is done in the context of interoperability. These findings are also relevant for this API framework proposal, which at its core is suggesting greater communication between departments to identify what work should be carried out as a priority independently by each

department, and what work is more conducive to cross-departmental collaboration, and how to set priorities accordingly. The report recommends the following approaches (Pinzon et al., 2019):

'An important facilitator of organisational interoperability is keeping track of stakeholders, identifying and involving them, and understanding their relationships and respective responsibilities. One segment of the stakeholders is the end users, who should be the main point of focus. The aim is to make the service available to them and not just to the government.

Successful organisational interoperability needs a political direction with the mindset of achieving better services and creating a clear view on the process of delegating tasks. To achieve this, there must be a willingness for trusted cooperation between the political sponsor and the departments that deliver the services and share information. Interoperability is only a tool for designing better services.

To reach the goal of better services and to create a clear view on the process of delegating tasks, it is also necessary to establish a clear hierarchy, as well as a strong coordination between the political direction and the participating department. The coordination aspects require both formal and informal agreements to be successful; to guarantee an independent implementation of those agreements, any coordinating tasks should not be handled at the political level. In certain circumstances, it can be preferable to first reach an agreement at an informal level and then allow access to commonly developed frameworks to a broader audience of interested parties in addition to the collaborating departments.'

— The **Italian regional government Regione Lombardia** created the E015 platform as part of a whole-of-government activity for the World Expo to demonstrate digital partnerships. This required a whole-of-government digital government coordinating body to work with individual departments and agree on priority activities. This included common elements across all departments, such as the single E015 platform infrastructure and developer portal, as well as individual departmental action to create APIs in their domain areas (Panebianco, 2019).

— The **'US Digital Services Playbook'** discusses key strategies that can be adopted at a tactical level to align policy with action, including prioritising activities, structuring budgets to support delivery, and assigning a single accountability manager (US Digital Service, 2020).

3.7 Proposal 6: Harmonise platform and ecosystems assets

Box 6. Summary of proposal 6	
Description:	Foster the establishment of domain-area ecosystems with relevant stakeholders. Build platform components that can be used by whole of government. Build components that can be used by domain-level ecosystems and by individual departments.
Application level:	Tactical
Pillar:	Platforms and ecosystems
Strength of evidence:	API platforms require a range of stakeholders to agree on a set of minimal common choices to enhance interoperability (including to adhere to common API standards, considering which shared data models must be commonly defined, define common architectural choices) and which service components can be reused and, sometimes, even the use of common tools.

3.7.1 Why this proposal is important

One of the results of our literature analysis indicates that the implementation of government platforms is still in its early stage. Some governments, for example, are focusing on cross-collaborative internal ecosystems that only involve government departments and public authorities working together in a given domain area, while others are creating ecosystems that involve external partners and stakeholders.

One of the challenges of an ad hoc approach to government APIs, identified in the literature, is that individual department-listed APIs make it difficult for government agencies to discover existing APIs available for reuse. External parties are also required to understand and be able to navigate all government departments in order to discover the APIs that might be of use to them.

Common enterprise IT architecture approach is suggested by the European Commission (European Commission, 2019a) and pursued several governments such as Finland, Denmark (Danish Steering Committee for Data and Architecture, 2017), Italy (Italian digital agency (AGID), 2018). A recent review by the Estonian Government's Chief Technology Officer has set forth a vision for 'next generation digital government architecture' which discusses the importance of API-enabled common architecture (Robinson, 2020). Some of these enterprise architectures establish the foundations on which API gateways and whole-of-government developer portals can be built, but the collected documents show that this work is in its infancy (Danish Steering Committee for Data and Architecture, 2017; Danish Ministry of Finance, 2018; Finland Ministry of Finance, 2018; Victorian Government, 2019b; US Digital Service, 2020).

There is also some debate on whether such approaches will be flexible enough to enable future-proofing of next generation digital architecture. Participants of our workshops, observed that adopting a too rigid centralised architecture (where all services must be routed through a single funnel) can be a barrier for further flexibility required by future government use cases. An example that was brought to notice, was the reliance on WS* (SOAP-based) frameworks in which 'common enterprise architecture infrastructure', in some cases, hindered co-creation of services and interoperability with the external stakeholders (Polli, 2018).

To overcome these challenges, the European Commission EIF proposes a series of interoperability principles and a set of interoperability layers both at the governance and operational levels (i.e. technical, semantic, organisational and legal). In line with the EIF, the definition of a 'common architecture' for government platforms should be interpreted on the use of standardised approaches at different layers, API-enabled infrastructure, and shared understanding of design patterns.

3.7.2 Implementation

At a strategic level, as also described in proposals 1-4, digital government leaders need to understand the policy context in which APIs will operate. At that level, under the platforms and ecosystems pillar, it was recommended that digital government leaders seek out and understand their government's preferred platform vision model. This is important because it can now be used to influence tactical decisions related to platform design, ecosystem participation and infrastructure resource allocation.

A whole-of-government digital government leadership team is needed to help steer discussions to ensure that common platform agreements are created and used uniformly by all departments. In line with the EIF interoperability layers, our analysis discovered that API platforms require a range of stakeholders to establish shared agreements on a set of components including:

— Prioritised ecosystems: Networks of stakeholders that participate in a domain area of expertise, such as transport, agriculture, etc. to identify common use cases and industry needs for APIs.

— Data registries: Shared data should be selected and analysed. A minimum set of common syntactic, e.g. format, and semantic, e.g. terms, properties and relationships, characteristics, should be discussed and agreed. In order to avoid ad hoc outputs, the reuse of existing and recognised models should be considered, such as for example Schema.org (Schema.org community, 2020). Single-source-of-truth datasets/core vocabularies can be reused to avoid complexity and duplication.

— Shared services: Common digital services that are reused as components in value chains. For example, an identity verification capability or a payments functionality can be built once and used in multiple departments' websites and mobile apps.

— Single inventory point, such as an API catalogue or an API portal: This allows internal or external stakeholders to access the documentation (which adoption should also be agreed) about shared services and data registries via API at a unique point in the web.

— Common shared technology standards: Agreements on standards ensure APIs are easily understood and replicable because they share nomenclature and other design elements.

— Shared legal agreements: To ensure that organisations operating under different legal frameworks, policies and strategies are able to work together.

One process to assist governments make resource allocation and priority decisions is to identify key exemplars that represent common operations that governments perform (such as registering the birth of a baby, setting work skills competencies, certifying health-related businesses, and calculating taxes). Each exemplar service is then documented in a detailed workflow to identify common services that are relevant to all government operations. For example, filling in a form, verifying identity, and making payments are all functionalities that are used in multiple government departments when operationalising digital services. These would make ideal candidates for creating shared services APIs that could be standardised and used by all departments (Thomson, 2015).

Individual departments would also need to identify ecosystem membership networks which are needed, based on the government's platform vision. For example, governments focusing on a platform vision in which they see their departments working collaboratively in a platform model will have a different ecosystem stakeholder composition than a government that has a platform vision that has identified creating new services in partnership with business and research. Work by the European Commission and by Member States to identify high value datasets and to create domain-driven data spaces will also help guide the prioritisation and membership of relevant ecosystems, and creation of ecosystems to inform API development should be deeply aligned with those work programmes.

At a tactical level, this proposal is focused on the allocation of resources and on the platform component decision-making processes. It is envisaged that during implementation of this proposal, IT and digital government leaders will work together to identify what ecosystems to create (and decide on membership composition based on the government's platform vision). They will also identify and prioritise the common platform components that are necessary for their government to build API-enabled infrastructure. Following this, proposal 10 then identifies tasks at the implementation layer such as documenting API infrastructure design patterns and publishing API style guidelines. Proposals 11 and 12 then implement these platform components each time a new API is built by the government.

While implementing the adoption of this proposal, it is also useful to assess the impact of it by using different metrics. Table 14 suggests some potential metrics to measure its success.

Table 14. Potential metrics to measure success of proposal 6

Type of metric	Metric
Possible output indicators	Existing or newly created organisation ecosystem boards would be established for key government priority areas to encourage interoperability and shared data models
	Standardised APIs and shared data models in place for each organisation
Possible outcome indicators	Greater range of products and services available to citizens and businesses that meet specific needs
	Faster creation of products and services for citizens and businesses co-created between government, non-profits, industry and citizens themselves
Possible impact indicators	Stronger local economies, greater satisfaction of citizens and businesses with available services and choices, more dynamic societies living within sustainability limits

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 15 illustrates a possible checklist to perform the evaluation.

Table 15. Maturity checklist of proposal 6

Maturity dimension	Question
Organisational infrastructures	1. Does government have a clear vision of how internal and external stakeholders should be engaged in an ecosystem approach?
	2. Has the government identified priority domain ecosystems (7) to work with and established a mechanism to enable participation of stakeholders?
	3. Is there a mechanism to ensure ecosystem work is cohesive and coordinated between ecosystems and with the government's wider API activities?
Organisational leadership	4. Is the appointed IT leader managing a documented enterprise architecture design pattern to enable API activities and encourage reuse, integration and interoperability?
	5. Is there an appointed information management leadership ensuring data models, data interoperability, data sharing and data protection are coordinated consistently across government?
Resource allocation	6. Has government set priorities for identifying, creating and sharing digital assets with APIs (including dynamic, high value datasets when available)?
	7. Has government set priorities for identifying and building shared services capabilities across government?
Skills	8. Are ecosystem members and government representatives supported to build their API skills, including in the importance and opportunity of using API standards, design thinking, and business model co-creation?
	9. Does the government's enterprise architecture avoid the development of ad hoc API solutions and enable deployment of API gateways and developer portal/API catalogue?
Metrics	10. Are measurements used to drive discussions on new funding models and on efficiencies generated from collaborative action?

Source: JRC, own elaboration.

(7)   A domain ecosystem is a network of stakeholders within a specific domain area of expertise and may include government departments, private industry, regulatory and public authority partners, representatives from other tiers of government, non-profits and community groups, academics, institutions and professional associations, and citizen advocates. Ecosystems can help governments define what API use cases to prioritise, encourage the use of shared data models, and foster the use of common API standards (own elaboration for this report).

3.7.3 Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **European Commission EIF** gives fundamental guidance to implementing interoperability among and within the public administrations, through a set of recommendations, to public administrations on how to improve governance of their interoperability activities, establish cross-organisational relationships, streamline processes supporting end-to-end digital services, and ensure that existing and new legislation do not compromise interoperability efforts. The EIF proposes an interoperability model which is applicable to all digital public services and may also be considered as an integral element of the interoperability-by-design paradigm (European Commission, 2017b). It includes:

  ● Four layers of interoperability: legal, organisational, semantic and technical;

  ● A cross-cutting component of the four layers, 'integrated public service governance';

  ● A background layer, 'interoperability governance'.

— Within the **ISA₂ programme** the European Commission has launched a series of initiatives for the interoperability of public administration, such as, for example, the Semantic Interoperability Community (SEMIC) initiative. SEMIC has developed a number of semantic specifications and interoperability solutions which are available to public administrations, namely: the eGovernment Core Vocabularies (European Commission, 2019b), the DCAT Application Profile for Data Portals in Europe (DCAT-AP) and the Asset Description Metadata Schema (ADMS). The 'handbook for using the Core Vocabularies', in particular, describes how the core vocabularies can be used by public administrations when creating APIs to attain a minimum level of semantic interoperability for eGovernment systems (European Commission, 2020d).

— In his detailed **Government-as-a-Platform** blog, Mark Thomson, former architect of the UK Government Digital Service, describes the process for identifying common capabilities across government and provides advice on setting an agenda for moving towards a Government as a Platform model built with APIs (Thomson, 2015).

— The **French Government's modernisation strategy** has proposed mobilising ecosystems and using web standards to encourage common data models, standardised APIs, a unique inventory point and collaborative efforts within government departments and with external stakeholders (French Secretary-General for the Modernisation of the Public Action, 2020).

— In **Italian digital strategy,** domain-driven ecosystems (that is, networks of stakeholders that share expertise in a common sector subject area, such as transport) are seen as central to assisting governments prioritise and deliver API activities (Agenzia per l'Italia digitale, 2019). In particular, ecosystems:

  ● support a citizen and business-oriented vision, leading to the creation of services that simplify interaction with public administrations;

  ● standardise the approach to the development of public administration services;

  ● stimulate interoperability;

  ● capitalise on the experiences gained by individual public administrations through the enhancement of best practice.

— In his presentation at our workshop on EU API strategies (European Commission, 2018c) **Ireland's Chief Information Officer** noted that challenges with their current data architecture have resulted in a lack of sharing of data across public bodies. It has also led to duplication in data storage and collection. The Irish government's vision for a more efficient data ecosystem is based on improving government operations by utilising APIs. They are currently introducing base registries (that is, single authoritative sources of data that are mandatory for public bodies to reuse, accessed by API); encouraging discoverability by publishing all APIs to a single catalogue; and creating an interoperability platform approach so that data and services can be reused across siloes (Warren, 2018).

3.8 Proposal 7: Establish cross-competency teams

Box 7. Summary of proposal 7	
Description:	All teams with responsibilities for managing APIs will require a range of skills including policy and programme understanding, product management, technical implementation skills, and community management and evaluation skills. Implementing government API activities requires a greater focus on collaborative capabilities, ecosystem facilitation, the ability to measure the value being generated, and design thinking skills.
Application level:	Tactical
Pillar:	People
Strength of evidence:	There is strong evidence from both government and private industry to show multi-disciplinary teams are best equipped to manage API-related activities.

3.8.1 Why this proposal is important

APIs are not just a technical concern but represent an organisational decision and are a technology enabler for implementing policies. They often require the involvement of policy and technical expertise. Therefore, API teams within government need involvement from both technical and policy/programme staff. This is modelled on best practices from private industry and from leadership API projects in government, such as the Finnish and European-wide city collaboration initiatives 6Aika and CitySDK. Both of these initiatives recommended technical and policy expertise in API teams.

Typical team compositions should include an API team leader who can act as a product manager to drive usage and ensure alignment with user need. The API team leader has also to communicate with the policymakers to ensure that APIs serve policy goals. When APIs are built, IT engineers can make decisions based on feasibility and technical best practices. But, sometimes, these requirements could change the focus of the API slightly. A product manager helps ensure that any changes do not fundamentally alter the original policy-oriented intent of creating an API.

Teams also include IT architects and developers/engineers. An API developer advocate or 'evangelist' will be needed to encourage use and to create resources that help internal and/or external users integrate the government APIs into their workflows and digital services.

As things currently stand, there are limited processes and content materials available at present to formalise training for the public service sector in APIs and in understanding their potential and role in the digitisation of government services. Government strategies show limited policy knowledge of APIs and their impact on redefining government through platform models, and instead focus mainly on integration capabilities at a basic level. Similarly, core concepts such as design-thinking, cross-collaborative working processes, and new models of governance do not have systemic training content available, yet these will be core skills areas required to implement an API infrastructure approach as described in this framework.

3.8.2 Implementation

Creation of documents (such as executive summaries) and training resources on understanding APIs and their role in government policy and service delivery will need to be prepared and delivered across government operations. Digital skills competencies will need to be updated to better reflect API knowledge (OECD, 2019b; Varteva, 2016).

Those involved with any digital government, digital innovation, or interoperability projects should be trained in APIs and design-thinking processes. This could be, for example, conducted through the following initiatives: the Interoperability Academy organised within the ISA$_2$ Programme (European Commission, 2019c) and the Support Centre for Data Sharing (European Commission, 2020e).

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 16 suggests some potential metrics to measure its success.

Table 16. Potential metrics to measure success of proposal 7

Type of metric	Metric
Possible output indicators	Departments would establish API teams with policy analysts, technical expertise, product managers, developer advocates, content creators, and data scientists
	Training resources in design thinking, ecosystem facilitation, cross-departmental collaboration, data sharing best practices and understanding APIs are available and delivered across government
	Government departments create templates to build consistent APIs that address policy and technical concerns
Possible outcome indicators	Cost-reductions across government operations as developers within government are able to discover and reuse APIs created, with ease
Possible impact indicators	Citizens and local businesses able to access a broader range of personalised services from government and industry because new products and services are built on reusable APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 17 illustrates a possible checklist to perform the evaluation.

Table 17. Maturity checklist of proposal 7

Maturity dimension	Question
Organisational infrastructures	1. Do policy, programme and IT teams meet regularly to oversee creation of the government's digital products, services and API activities?
Organisational leadership	2. Do policy, programme and IT teams assess user needs alongside organisational policy goals to continually refine priorities?
	3. Are champions identified in both programme and IT teams to encourage API-first approaches?
	4. Do departmental leaders and decision-makers work with policy and programme staff to take an API-first and product approach to managing APIs?
Resource allocation	5. Do policymakers, programme and IT teams members attend any established ecosystem network meetings?
	6. Has government set priorities for identifying and building shared services capabilities across government?
Skills	7. Do policy stakeholders within government inform sufficiently to help guide programme activities towards using APIs where appropriate?
	8. Are all programme teams able to design and deliver APIs where appropriate?
Metrics	9. Are measurements reported, shared and discussed during joint meetings between policy, programme and IT teams?

Source: JRC, own elaboration.

3.8.3 Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **Open API Recommendations for cities guide from 6Aika** which provides some advice on forming best practice, multidisciplinary teams to manage and implement API strategies (6Aika, 2019a). Finland's 6Aika project recommends creating a management team for each API being released by a government department (Varteva, 2016). This team should be responsible for answering the following key questions:

  ● Who owns the service?

  ● Who is responsible for content maintenance?

  ● Who is responsible for content development?

- Who is responsible for technical maintenance?

- Who is responsible for technical development?

- Who is responsible for service communication?

— In a paper reviewing the **reorientation architecture required to manage government-as-a-platform infrastructure, Fujitsu** recommends that government teams be skilled in design thinking and an understanding of technology opportunities. They note that the ability to 'equip government teams with the skills, technology and design thinking that is required for transformation' is key (Fujitsu, 2015).

— The **US Congress has legislated** to lead evidence-based policymaking by ensuring that the US Federal Government has access to an 'online repository of tools, best practices, and schema standards to facilitate the adoption of' APIs (that is, 'machine readable open data practices') (US Congress, 2019).

3.9   Proposal 8: Follow an API product approach

Box 8. Summary of proposal 8	
Description:	Governments need to allocate resources to manage APIs as ongoing assets in a programmatic way. As governments move toward a platform model, more stakeholders will grow reliant on government APIs to create and provide products and services. These products and services will need to be confident that the government APIs they are using as 'raw goods' are available and working as expected. An API product approach ensures government departments allocate the resources and systems necessary to build this ecosystem confidence and ensure value is generated from APIs.
Application level:	Tactical
Pillar:	Processes
Strength of evidence:	Strong evidence from private industry advocates for the use of API as a product approach. Workshop feedback and key informant interviews warned against governments under-resourcing APIs as pilot and one-off projects, as it limits economic opportunity and growth for external stakeholders. There are growing examples of governments taking a product approach, particularly in statistics, transport, and weather API delivery. However, these are still fairly limited and are often resourced at a minimum acceptable level and do not fully demonstrate the potential value creation that can be harnessed by resourcing APIs adequately.

3.9.1   Why this proposal is important

Governments often deliver ongoing services in the form of programmes. Short-term pilots or time-limited projects are also conducted to meet specific targets or address more short-term needs. When introducing APIs into government, departments need to think of APIs being akin to programmes, or, in private industry terms, products (8). This means that they are treated as medium- to long-term assets that must be maintained, rather than as one-off or pilot projects. They will require sustainable and updated documentation for a range of user groups. They will need to be regularly reviewed, improved and updated. Their usage will need to be tracked to ensure they are providing value and meeting organisational goals. If they are not proving useful or creating value, they should be deprecated.

Clear permissions and rights of use for an API are also part of API product management (6Aika, 2017a). Once APIs are available and documented as reusable components for workflows, products and services (either within government or exposed to third parties), users need to be confident that the API is available, performant, and permissible. Availability means that it is able to be found and understood, for example, on a government's API catalogue and that it does not stop working unexpectedly. Performant means that it feeds data or services in a timely and consistent manner. Permissible means that end users understand their responsibilities and have an appropriate level of security and authorisation to use the API functionality for their use case. For example, external users will need to know that they are allowed to use government APIs in a commercial product. Also, maximum attention must be guaranteed to protect the privacy of sensitive information and external users do not have access to private citizen data used by internal government APIs.

Few governments are resourcing and managing APIs in an ongoing, programmatic way at present. While there are some examples of mature APIs being delivered by governments, the main issue at present is that for most governments, creating and making APIs available are seen as 'pilot' projects that are not yet resourced as programme/product approaches that are managed as ongoing, budgeted resources.

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(8)   A product approach is now considered best practice in private industry, and emerging best practices from government stress the importance of treating APIs as ongoing, programmatic resources being managed by a department. However, the appropriate level of oversight and programme management of APIs is unclear. Proposals in this API framework suggest taking a product approach to APIs in order to encourage governments to resource API activity appropriately, but how governments might manage this is yet to be determined and will need to be tested to find the right fit, which may vary from organisation to organisation.

3.9.2 Implementation considerations

All government APIs should be used internally first and be used for the provision of requested internal and external services. When identifying use cases for creating service and dataset APIs, internal use cases should be prioritised. That is, the API should be used internally to drive information flow or enable functionality within or between departments. This will help ensure that APIs deliver value and that they are robust and performant.

Each API should define service-level objectives or expected standards of performance for internal stakeholders and, eventually when opened to wider audiences, how they are expected to perform and be used when exposed to third parties. Service-level indicators can be used as measures to ensure departments are achieving their objectives or are addressing shortfalls.

APIs should be budgeted and resourced for ongoing use, including budgeting and resourcing to enable people to take on a product manager role and utilise associated tooling.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 18 suggests some potential metrics to measure its success.

Table 18. Potential metrics to measure success of proposal 8

Type of metric	Metric
Possible output indicators	Government APIs would be managed by teams with a product manager overseeing and maintaining delivery
	Licensing templates would be in place across government to ensure that usage of APIs is guaranteed and stimulates new product development and business opportunities
	Government departments create templates to build consistent APIs that address policy and technical concerns
Possible outcome indicators	The creation of standard API licensing templates can speed up and standardise adoption of licensing across government departments, reduce workloads and increase adoption by third parties (by avoiding overcomplexity in licensing conditions)
Possible impact indicators	Greater range of products and services built using government APIs as a 'raw ingredient' as industry has greater confidence in the maintenance and ongoing availability of government APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understand how the current organisational status is ready or has been prepared to adopt it. Table 19 provides a possible checklist to perform the evaluation.

Table 19. Maturity checklist of proposal 8

Maturity dimension	Question
Organisational infrastructures	1. Are there plans and processes in place to manage new use-case and feature requests, service interruptions and to manage security breaches?
Organisational leadership	2. Are licensing agreements in place for each API including internal, partner and external-facing APIs, and are service level agreements in place and monitored regularly?
Resource allocation	3. Are government APIs that have been created for external use also used for internal use when accessing data or services?
	4. Are support services including a dedicated email, ticketing system and help desk available for API consumers?
Skills	5. Does each API have service-level objectives that define expected standards of performance for internal stakeholders and, when opened to wider audiences, how they are expected to perform and be used when exposed to third parties?
	6. Is there good documentation in place for each API which answers the following questions: — What can I do (and not do) with this API? — How do I secure the API? — How long will it take to get started? — What API endpoints and event integrations does the API offer?
	7. Are user personas and use cases documented and prioritised for each API?
	8. Are APIs discoverable through a variety of means relevant to each user persona?
Metrics	9. Are errors, usage patterns, onboarding and retention processes monitored to support engagement and are these compared and reported against priority use case and user persona needs?
	10. Are API activity monitoring and metric systems embedded into regular programme operational approaches?

Source: JRC, own elaboration.

3.9.3   Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include:

— The **Canadian Government's API guidelines** recommend taking an API-as-a-product approach. They describe an approach based on four actions (Government of Canada, 2019):

- Consume what you build and pilot internally

- Support the API throughout its lifecycle

- Measure and publish API benchmarks

- Publish and document the API.

— The **Swedish Transport Administration,** uses the **Swedish API licence,** a licensing template especially designed for the Swedish legislative context and built on the Creative Commons By 3.0 licence. The use of a standard licence as a source has reduced their workload and avoided unintentionally creating overly complex licensing arrangements (Swedish Governmental Agency for Innovation Systems, 2020).

— The **6Aika API Toolkit** resources help public service practitioners to understanding the role of APIs and their potential and provides recommendations for encouraging standardised, best practice approaches to government API service delivery (6Aika, 2017b).

— The European Commission provides a couple of assistants to choose the right licence: the **JoinUp Licensing Assistant** (JLA) and the **European Data Portal (EDP) licensing assistant.** The JLA is a tool that allows everyone to compare and select licences based on their content (European Commission, 2019d). The EDP licensing assistant provides a description of the available licences. It also gives an overview on

how to apply licences as re-publisher/distributor of open data and how to combine multiple licences (European Commission, 2020f).

— The **Australian Government's Digital Transformation Office** promotes continually improving APIs and meeting performance standards (Australian Government, 2019). They recognise that high-quality API product management involves the following:

- 'An API that is consistently rated as hard to use should be remediated. Ensure less than 20 % of feedback rates the API as hard to use.

- There should be only one API function for one business outcome (e.g. change an address).

- Error messages should provide a human-readable error message that is designed to be read and understood by the user.

- Error messages should include a diagnostic message that contains technical details for use by the developers/maintainers of the application that consumes the API.

- All APIs should have a published SLA and behave accordingly.

- Publish API documentation and provide a link to the documentation from the API endpoint.'

— The **UK's Digital Services recommend government departments** should focus on developer experience when opening APIs. This involves making sure APIs are 'as approachable as possible with:

- Good documentation

- Consistent and meaningful naming conventions

- Simple usage examples

- Use specific online community tools

- Make sure error messages are explicit and on the point.' (UK Government, 2019a)

3.10 Proposal 9: Measure policy impacts of APIs

Box 9. Summary of proposal 9	
Description:	The value of APIs needs to be measured in an ongoing and transparent manner in the same way that any government programme must be monitored to ensure it is performing as expected and creating value for citizens, businesses and the environment. APIs should be measured to ensure they are performant, are delivering value for government and for ecosystem stakeholders, and that they are not inadvertently causing any harm or widening inequality.
Application level:	Policy support
Pillar:	Operational
Strength of evidence:	While there is sufficient evidence to demonstrate how to monitor APIs from a technical aspect, there are few examples beyond one-off, specific research studies that measure the efficiency and policy value being generated by APIs. Private industry also offers fairly weak evidence as their focus is predominantly on revenue-generation metrics and on API technical performance metrics. Industries including banking, weather, and transport have yet to create standard systems to measure the value being generated by open APIs.

3.10.1 Importance

As industry use of APIs has matured, analytics have been introduced to monitor the impacts of APIs. The three main types of metrics introduced for APIs are:

— **Performance:** Metrics for APIs were initially introduced to ensure APIs were robust and performant. Uptime, security, and response rate, for example, helped API technicians ensure their service level objectives were met. This is the most common form of measurement and is often carried out by business as well as government.

— **Strategic value:** As APIs increasingly became recognised as a way for businesses to deliver on their strategic goals, key performance indicators were introduced to better measure API impacts on business goals, such as the ability to bring in revenue, or to increase engagement with particular target markets. This is emerging in private industry as an important metric for ensuring APIs are built with organisational value but is not, as yet, a common approach within government.

— **Ecosystem impact:** In line with a product management approach (9) to APIs, alongside measuring the business benefits of APIs, new measures to ensure third party adoption were introduced, for example, to measure the time it takes for a new developer to start using an API (referred to as Time To First Hello World, or TTFHW). Other measures include developer satisfaction and likelihood to recommend an API to their peers (called Net Promoter Score). These metrics are often collected by both business and government, particularly by measuring adoption uptake of an API or by sharing examples of how the APIs are being used by external stakeholders.

Government API teams can measure these three types of metrics, but must also consider if APIs can cause any detrimental impacts. For example, if the government is introducing APIs to expose large datasets to machine learning, governments need to measure whether the resulting algorithms are introducing any bias that creates inequality or marginalises any particular population. If APIs are provided free of charge to all users, API teams need to ensure that they are not inadvertently giving an advantage to large tech giants over local SMEs. Monitoring the potential for negative impacts of APIs is an essential part of a government API policy impact measurement system.

There was limited evidence to demonstrate that API teams are creating analytics systems for their APIs as part of a product management and lifecycle approach. The literature suggests they do not currently identify possible

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(9) A product management approach recognises the need for ongoing maintenance of APIs once they are introduced. This includes maintaining communications and engagement with developer and ecosystem communities, ensuring documentation is updated, that error messaging for developers provides sufficient guidance, that APIs are discoverable, and that adoption rates are monitored to ensure that APIs have a high value both internally and publicly.

ways to measure their strategic value and to measure potential negative societal impacts of the APIs under their remit. Appropriate measures should be identified at the API level, when designing metric collection and analysis at an operational level.

Some research has been done to identify the value being generated by APIs within government. However, these studies are often one-off projects. Their findings do not seem to be influencing governments to systematically calculate the contribution APIs are making in creating these wider societal, economic and environmental impacts.

3.10.2 Implementation

In workshop activities and key informant interviews, government stakeholders confirmed that they are measuring the performance/technical aspects of APIs. Literature and industry examples are available to assist governments implement performance metrics and this should be done as part of an API lifecycle approach [10] (as described in proposal 12). To begin measuring the policy value of APIs, governments might revisit their impact assessment processes conducted as part of their initial analysis of the policy outcomes that APIs can support (see proposal 1). These impact assessments can be used to identify potential indicators that should be monitored regularly to understand which impacts are introduced when implementing API activities.

Governments should also have identified priorities and potential metrics approaches as part of proposal 5. The approaches to measuring the value of APIs in contributing to policy outcomes that were discussed in proposal 5 can now be operationalised at this stage. It is often best to start with one or two metrics and to improve how data is collected, reported and analysed over time.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 20 suggests some potential metrics to measure its success.

Table 20. Potential metrics to measure success of proposal 9

Type of metric	Metric
Possible output indicators	Each government API's metrics plan would include at least one measure to assess the API's impact on broader policy goals
	New impact assessment tools would be available that help decision-makers assess the environmental, societal and economic impacts of an API strategy, possibly since the beginning of their use
Possible outcome indicators	More responsive policymaking environment in which negative societal impacts from newly emergent technologies are identified early and negative impacts deflected and reoriented towards positive outcomes
Possible impact indicators	Increased inclusion and access of the benefits of APIs are shared by all members of society
	Government able to take an experimental and iterative approach being confident in not causing greater harm
	More sustainable (that is, more efficient, less use of energy and other resources, less duplication) government operations

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 21 illustrates a possible checklist to perform the evaluation.

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[10] Alongside a product management approach, APIs should be designed with a full API lifecycle approach. This requires that APIs serve a clear business purpose and that APIs are first described via metadata, for example, by using an API specification format file such as the Open API Specification (OAS) standard. By describing the API's purpose and functionalities in a specification file, as the API is designed and built, the specification can be used to ensure that the design did not differ from the intended purpose. Specification files are often used in automated API design lifecycle software to spin up versions of sandboxes (testing environments), basic documentation and programming libraries (SDKs), and can be used to help guide test-driven development best practices. An API lifecycle approach also allows APIs to be updated and versions maintained and decommissioned.

Table 21. Maturity checklist of proposal 9

Maturity dimension	Question
Organisational infrastructures	1. Have the order of implementation of API activities for the whole of government and for each department been prioritized?
Organisational leadership	2. Do departmental leaders regularly consult policy stakeholders to review metrics to ensure that API activities are enabling policy goals to be achieved?
Resource allocation	3. Are processes in place to ensure metrics are standardised wherever possible for API activities and regularly collected, reported and analysed, and that corrective actions are implemented, where necessary?
Skills	4. Is there an understanding and use of output, outcome and impact indicators to measure API activities?
	5. Are metrics systems, analysis and reporting processes automated across the organisation?
Metrics	6. Are metrics able to identify potential differential impacts for particular stakeholders?

Source: JRC, own elaboration.

3.10.3 Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **European Commission's Better Regulation Toolbox** provides guidance on how new technologies should be assessed. The scope and depth of technology impact analysis should be proportionate and consistent with the importance/type of initiative and the nature and magnitude of the expected impacts. These techniques could be adapted to measure API impacts. Guidelines include a section on how to monitor and measure technology impacts, including outputs (activities undertaken that are assumed to generate value), outcomes (early indicators that actions are successful), and impacts (longer-term value being generated by activities (European Commission, 2017c).

— The **European Commission's GeSi** funded digital government initiative promoted the use of the sustainable development goal indicators to help identify whether benefits are being experienced by all population groups, in all areas and within sustainable resource limitations (GeSI, 2020).

3.11 Proposal 10: Build API platform components

Box 10. Summary of proposal 10	
Description:	At a strategic level, the government's platform model has been defined. At a tactical level, the government's common platform components and ecosystem stakeholders have been mapped. Now, at an implementation level, platform components are built and operationalised. This includes also supports such as API style guidelines, and documented design patterns.
Application level:	Operational
Pillar:	Platforms and ecosystems
Strength of evidence:	There is strong evidence from government that documenting infrastructural design patterns and mandating common API style guidelines helps to create future-proofed, robust API infrastructure. This is also a common practice in private industry.

3.11.1 Importance

The lack of assertive statements that encourage adoption of APIs and API architectural styles (such as REST), wherever possible, is slowing down efforts to move towards digital government service delivery. Recent documents such as the 'Summary report of the consultation on the review of the directive on the reuse of public sector information' (European Commission, 2018d) noted that because APIs were not clearly discussed as a strategic action in the first directive, limited work on creating dynamic datasets has been able to be pursued to date. The new open data directive has then clarified its strategic goal of ensuring APIs are used to share dynamic and high value datasets.

Similarly, interoperability strategies have been successfully used to share information with WS*/SOAP-based architectures but, in some cases, have been delayed with external stakeholders that have not clearly stipulated APIs. APIs adoption could reduce complexity, allow more flexible interactions, and permit a more lightweight learning curve and adoption, especially when dealing with government external stakeholders.

A key challenge for the European Commission when encouraging uptake of digital government goals, is to find the right balance between being overly prescriptive on technology choices versus building common interoperability platform components, such as, for example, the European Commission CEF building blocks (European Commission, 2019a) and the European Commission European Interoperability Reference Architecture (EIRA) (European Commission, 2020g).

3.11.2 Implementation

While governments may be reluctant to mandate APIs for all of government operations, best practices suggest that APIs should consider being built using web standards such as the REST architectural style (most common request-response conversational pattern) or event-driven architectures. For example, regular monitoring of existing legacy architecture can then calculate whether there are any efficiency or cost gains that could be achieved by moving some of the existing WS*/SOAP-based approaches to REST.

Leadership governments are creating style guidelines that document internal practices and standards for the creation of APIs. These guidelines often propose the REST architectural style as implementing the request–response pattern, especially for the exchange of the information with external stakeholders, the use of API portals/catalogues, API specification (metadata) files, naming conventions, security requirements, legal measures to protect privacy and regulate ownership and use, and approaches to versioning.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 22 suggests some potential metrics to measure its success.

Table 22. Potential metrics to measure success of proposal 10

Type of metric	Metric
Possible output indicators	Architecture design patterns would be adopted by governments that demonstrate how data and service functionalities can be shared across government departments and across borders
	A single developer portal and a single catalogue would be available for all government APIs
	Adoption of one or more API gateways
Possible outcome indicators	Faster product and service development as reuse of existing components is enabled
	Future-proofed IT infrastructure and ability to reinvest capital costs into creating services and features that increase productivity rather than manage or reorient ageing infrastructure
	Adoption of search techniques (e.g. with AI algorithms) and of semi-automatic metadata generation tools to speed up API discoverability and documentation
	Potential to introduce automatic recommendations of useful APIs to speed up the search of stakeholders
Possible impact indicators	Number of external stakeholders' applications based on the external APIs
	Number of developers using external APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 23 illustrates a possible checklist to perform the evaluation.

Table 23. Maturity checklist of proposal 10

Maturity dimension	Question
Organisational infrastructures	1. Are governance structures in place that assess new APIs against internal API style guidelines?
	2. Is there oversight of how authorisation, identity management and access permission rights are managed alongside oversight of the handling of sensitive data, data protection, audit and fraud detection?
Organisational leadership	3. Does IT leadership have an API-enabled enterprise architecture model documented that promotes coherence, innovation and efficiency?
Resource allocation	4. Is there an IT/enterprise architecture modernisation strategy that has identified cost–benefit analysis for when to keep legacy APIs and when to build RESTful APIs?
Skills	5. Do decision-makers understand the value of APIs in helping achieve policy goals enough to resource IT architectural modernisation efforts?
	6. Is a work programme to modernise and implement enterprise architectural changes that enable APIs in place and being implemented by IT teams?
	7. Have API style guidelines been documented and agreed upon?
Metrics	8. Is performance data on enterprise architecture's capacity to manage API usage efficiently collected and monitored?
	9. Is API usage measured to analyse the need for evolution in enterprise architecture?

Source: JRC, own elaboration.

3.11.3 Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— The **European Commission CEF Building Blocks** establish a series of capabilities and digital artefacts which are basic capabilities that can be reused in any project to facilitate the delivery of digital public services across borders and sectors (European Commission, 2020g).

— The **European Interoperability Reference Architecture (EIRA)** is a four-view reference architecture for delivering interoperable digital public services across borders and sectors. It defines the required capabilities for promoting interoperability as a set of Architecture Building Blocks (ABBs). The EIRA has four main characteristics: common terminology to achieve coordination, reference architecture for delivering digital public services, technology- and product-neutral and a service-oriented architecture (SOA) style, alignment with EIF and TOGAF (European Commission, 2019a).

— The **OECD: Unlocking the Digital Economy – A Guide to Implementing Application Programming Interfaces in Government** provides detailed advice on considerations for implementing best practice, evidence-based API architecture by governments (OECD, 2019b).

— The **Estonian Government,** identified several necessary steps including (Kütt, 2016):

- Adopt an API-first policy of enabling things rather than providing things;

- Take control of architecture;

- Build an authorisation solution to enable APIs to handle sensitive data;

- Invest in data protection, audit and fraud detection;

- Discuss with end users;

- Treat open data as APIs;

- Build open data into new systems;

- Develop prototypes and reference architectures.

Estonia recently reoriented their **X-Road infrastructure towards REST APIs** (Kivimaki, 2019) and to ensure greater value from their API-first approach.

The latest vision paper for the **Next generation digital government architecture** from the Estonian Government's Chief Technology Officer outlines the architecture and infrastructure model needed to use APIs for digital government and platform delivery (Vaher, 2020).

— The **Italian Government's Digital Transformation Team** has affirmed the use of RESTful APIs based on government experience and interaction with third party users. In 2005, Italy created the SPCoop standard for interoperability in the public sector. This was a SOAP-based, 4-corner integration approach, but 12 years after introduction, only 200 agencies were able to deploy and afford this common infrastructure, while smaller organisations and local cities were not. The largest barriers to widespread adoption were the closed nature of this approach, that it required 1:1 contracts to be signed for each implementation, and because this 'mandatory infrastructure' was only designed around government-to-government use cases. They reviewed the technical literature and noted that REST was the 'de facto standard in the private market' and various agencies started implementing REST-based APIs in 2013, which were opened to the private sector. They found this to be a successful pilot as REST was easier and cheaper to implement, and enabled engagement with private sector actors. In 2017, this model became central to their 3-year whole-of-government strategy which includes REST APIs written with open API specification, where possible; market-driven API standards; iterative upgrades and versioning of government APIs; a public API catalogue; and self-serve access to appropriately secured APIs. Their architecture model remains bimodal and allows existing SOAP services to continue operating (Piunno, 2017).

— The **Belgian government** has created REST guidelines in recognition that 'The main benefit for choosing RESTful services is to increase flexibility and to offer web service support to client platforms not able to communicate using SOAP web services' (Belgium Government, 2020). They noted that:

- REST is the de facto standard to communicate with web services from JavaScript and native mobile applications;

- REST has become the industry standard for developing APIs on the web.

— The **Netherlands government** has released an API strategy that states that the government 'aims to describe a set of design rules for the unambiguous provision of RESTful APIs (henceforth abbreviated as

APIs). This achieves a predictable government so developers can easily start consuming and combining APIs.' (Geonovum, 2019).

— The **UK Government Digital Service Guidance on Open API Specification** guidance note provides a good example of why, as part of a lifecycle approach, a government would encourage adoption of an API specification file for RESTful APIs, and how to implement this as a best practice (UK Government, 2019b).

3.12 Proposal 11: Appoint API product manager(s) and teams

Box 11. Summary of proposal 11	
Description:	Product managers, or owners, are needed to ensure APIs can be managed as an ongoing resource within government. These programme leads are responsible for ensuring that APIs are usable and accessible, and that they align with policy and ecosystem goals. Product managers are also usually responsible for identifying potential improvements to an API, and facilitating discussion between users and the engineers creating and managing the technical aspects of APIs.
Application level:	Operational
Pillar:	People
Strength of evidence:	Both government and private industry stress the importance of appointing product managers to 'own' each API so that they are delivering the value that is expected. This also ensures sustainability in the resources used for the API creation and ongoing resourcing.

3.12.1 Importance

The optimum organisational structure within government for such an approach is not yet clear. For example, some governments have multiple APIs that are managed together by a service manager. It is unclear at present whether a service manager model should manage multiple APIs, or whether each individual API also needs a product manager. In any case, each department offering government APIs would need to appoint a staff member to be product manager for each API, or group of APIs. Job descriptions, tasks and performance indicators will need to be prepared that reflect the product management duties to be performed.

After a sustainable programme on API adoption mindset has been adopted at the departmental level to help decide resource allocation (see proposal 8), then department staff members will need to be appointed as API product managers alongside developer teams. These product managers will be responsible for leading design thinking processes where user needs are considered upfront (Kennan, 2018), creating developer resources (such as documentation), and for ensuring that support to developers consuming the government APIs is delivered in line with service level objectives. The product manager would work closely with the API technical lead and developer teams to ensure APIs can achieve intended policy goals, and match use cases. The product manager would implement processes to collect and report on metrics (see proposal 9). An API product manager could also assist with maintaining communications with the domain ecosystem of stakeholders (see proposal 6).

3.12.2 Implementation

Each department managing APIs needs to appoint a staff member to be overall product manager for each API, or group of APIs that make up a digital service. Job descriptions, tasks and performance indicators will need to be prepared that reflect the product management duties to be performed.

The product manager should have overall responsibility for ensuring that APIs are discoverable, easy to use, are documented, and see increasing adoption amongst those who can receive value from them. The product manager works with technical leads and technical teams to ensure that APIs are performant, used efficiently within resource constraints, and maintain high security and data privacy standards. The product manager communicates with policy managers to identify use cases and new features and monitors how the APIs are creating value in line with expected policy goals, without increasing detrimental impacts on communities and local economies.

While implementing the adoption of this proposal, it is also useful to assess its impact by using different metrics. Table 24 suggests some potential metrics to measure its success.

Table 24. Potential metrics to measure success of proposal 11

Type of metric	Metric
Possible output indicators	Job descriptions mentioning product management skills and duties
	Each API is assigned a product manager. Product managers across government are encouraged to collaborate and share skills and approaches to API design and interoperability.
	API documentation available for each government API
Possible outcome indicators	Greater adoption of APIs internally and with third parties
	Lower costs of managing APIs as over time usage analytics and improvements to documentation reduce problems in adoption and increase efficiency in usage patterns
Possible impact indicators	Increased number of accesses to external APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 25 illustrates a possible checklist to perform the evaluation.

Table 25. Maturity checklist of proposal 11

Maturity dimension	Question
Organisational infrastructures	1. Do governance structures at departmental and whole-of-government levels monitor service level agreements, activity and usage of APIs (that is, what APIs are used for, and what value they generate, not just usage and performance statistics)?
	2. Is there a structure in place for ensuring that APIs are performant and meet service level objectives across the organisation?
Organisational leadership	3. Is each API managed by an owner and/or team?
	4. Do departmental leaders and decision-makers work with policy and programme staff to take an API-first and product approach to managing APIs?
Resource allocation	5. Are all APIs budgeted and resourced for ongoing use (as programme/product budgets), including budgeting and resourcing for a product manager and associated tooling (for example, a documentation portal)?
	6. Are APIs resourced as ongoing programme elements (not as pilots or projects)?
Skills	7. Do department leaders understand the implications and importance of: • identifying and prioritising key use cases for the specific API; • setting service level objectives; • identifying appropriate licensing arrangements on accessing APIs, source code and the underlying dataset?
Metrics	8. Are error messages for each API explicit and do they guide action with appropriate links to documentation?

Source: JRC, own elaboration.

3.12.3 Supporting evidence literature

Key resources that can be used to assist with implementing this proposal include the following:

— **Finland's 6Aika project** identifying best practices for harmonised city API standards recommend focusing on user documentation as a key aspect of API product management (6Aika, 2017c; 6Aika, 2019a). They suggest that 'Good documentation' answers the following questions:

● 'What can I do (and not do) with your API?

● Does your API fit my company's needs?

● How does your API view my world?

- How do you secure your API?

- How long will it take to get started?

- Do you offer SDKs?

- What API endpoints and event integrations does your API offer?

- Why am I getting this error code or unexpected response?'

— In this blog about **'Some Questions To Ask When Quantifying Your Organisational API Maturity':** the API expert Kin Lane identifies a useful series of self-assessment and discussion questions that a product manager could lead to manage their API strategies (Lane, 2019).

— The **UK Government's Guidance on Documenting APIs** provides a checklist for best practices that a government product manager can review when documenting and ensuring ease of use of APIs (UK Government, 2019c).

3.13 Proposal 12: Adopt an API lifecycle approach

Box 12. Summary of proposal 12	
Description:	An API lifecycle approach ensures that APIs are well designed, meet policy and organisational needs, have been tested to ensure they work, perform as expected, are secure and efficient.
Application level:	Operational
Pillar:	Policy support
Strength of evidence:	There is strong evidence that an API lifecycle approach is the most efficient, sustainable and effective way to design, create and manage APIs in both government and private industry.

3.13.1 Importance

API lifecycle approaches ensure best practices on API management are followed by an organisation. Within an API lifecycle approach, working on API design guidelines is one of the most advanced areas of API activity by governments worldwide. But, while this is necessary, it is not sufficient to implement a complete lifecycle that should include other aspects in addition to web development and software design (Google, 2019), including: matching API design with policy needs and use case descriptions (through, for example, metadata specifications), using iterative development cycles, testing APIs to make them are robust and performant, adopting API security and privacy measures (World Bank, 2018) and monitoring and maintain APIs to obtain the desired efficiency, sustainability and performance quality requirements.

3.13.2 Implementation considerations

API lifecycle management components should cover the following aspects: strategy, design, documentation, development, testing, deployment, security, monitoring, discovery and promotion, and change management (Mehdi et al., 2018). Best practices on implementing these components have been documented by several government authorities around the globe:

— Define appropriate authentication, authorisation and access permission policies for APIs (Geonovum, 2019).

— Ensure standard metadata specifications were created for each API. Where possible using well recognised documentation standards, such as OAS, with the participation of both policy and technical leads to describe the purpose and use cases of an API before technical design (6Aika, 2017c).

— Create API design guidelines (Geonovum, 2019).

— Ensure cybersecurity and data privacy controls are in place (UK Department for Business, Energy & Industrial Strategy & Cabinet Office, 2013; World Bank, 2018).

— Adopt API lifecycle design tooling with ability to set organisational standards so that any design outside of agreed internal standards would be alerted during development.

— When suitable, adopt agile development methodologies ([11]) amongst API teams to iterate and continue development by optimising efficiency and developing within resource constraints (US Digital Service, 2020).

— Define testing processes and DevOps processes, adopt continuous delivery/continuous integration and continuous improvement processes (Mehdi et al., 2018).

— Ensure API performance and usage data is monitored (US Digital Service, 2020).

([11]) Agile is a process of working that avoids large budgets with long development times in favour of iterative, experimental development in short implementation cycles. In this process, where basic APIs are built first, and once these have been proven to add value, they can be extended with additional features. Agile processes are more productive and less costly. Basic, initial versions of an API may be useful and be generating value even without all of their features available. Any problems in design can be identified early in the process and rectified rather than waiting until significant investment and time has been made before being testing in production settings.

While implementing the adoption of this proposal, it is also useful to assess the impact of it by using different metrics. Table 26 suggests some potential metrics to measure its success.

Table 26. Potential metrics to measure success of proposal 12

Type of metric	Metric
Possible output indicators	API style guidelines would be available at the whole-of-government level
Possible outcome indicators	Consistent, standardised APIs are created that meet user needs
Possible impact indicators	Greater economic development as third party stakeholders are able to scale new product and workflows using government APIs
	Greater citizen and business choice of products and services as third parties able to quickly make use of government APIs

Source: JRC, own elaboration.

Evaluating the maturity of the adoption of the proposal is also fundamental to understanding how the current organisational status is ready or has been prepared to adopt it. Table 27 illustrates a possible checklist to perform the evaluation.

Table 27. Maturity checklist of proposal 12

Maturity dimension	Question
Organisational infrastructures	1. Are governance structures in place to ensure new APIs adhere to internal guidelines and agreed use of standards?
Organisational leadership	2. Are APIs overseen by a product owner working in partnership with a technical lead who together regularly review performance, usage, value generation and alignment with policy and use-case priorities (12)?
Resource allocation	3. Are agile methodologies considered, and adopted where appropriate?
Skills	4. Are API lifecycle/style guidelines used to create APIs consistently and covering: strategy, design, documentation, development, testing, deployment, security, monitoring, discovery and promotion, and change management of APIs?
	5. Does each API have a metadata description in a standardised format (for example, OAS for REST APIs, AsyncAPIs for Event Driven Architectures APIs, ISO19119 for OGC services and WSDL for WS*-based architectures)?
	6. Are appropriate authentication, authorisation, cybersecurity and data privacy risks identified and addressed for each API?
	7. Are continuous integration/continuous delivery (CI/CD) processes in place and automated, where possible and in line with risk profiles?
	8. Are clear API versioning and deprecating policies in place?
Metrics	9. Are error messages for each API explicit and guide action with appropriate links to documentation?
	10. Is API performance and usage data monitored regularly?

Source: JRC, own elaboration.

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(12) In our context, i.e. in a user-centred approach to digital services and API design and prioritisation, an important initial tool is to define key relevant use cases and assign priorities to them. This can be done by cross-agency collaborative bodies, by domain ecosystem networks or by individuals leading government digitisation efforts. One example is the UK government's exemplars model which identified 25 common government operations where citizens and businesses interact with government, such as registering to vote, applying for a business registration, or updating driver's licence details. This example of process helped identify common datasets and shared capabilities required across use cases, which helped in setting priorities for which APIs should be created first.

3.13.3 Key resources

Work on API design guidelines is one of the most advanced areas of API activity by governments. Design (or style) guidelines, once agreed, can then be used by governance structures to assess new APIs and ensure they meet organisational requirements (see proposal 3).

Key resources that can be used to assist with implementing this proposal include the following:

— The **6Aika web API guidelines and lifecycle best practices** offer a set of valuable indications designed and validated by six city governments across Finland (6Aika, 2017c).

— Security issues are very important and need to be illustrated and linked to current examples. **Guidelines such as the US Department of Health and Human Services' Privacy and Security Consideration for APIs** provides significant detail on best practice security guidelines for APIs built that could expose a citizen's health data (US Government, 2017).

— The **Victorian Government API Design Standards** are a good example of API design best practices that guide government departments when they are creating and managing APIs (Victorian Government, 2019a)

— The **Netherlands API strategy** guidelines include recommendations on API design and lifecycle approaches (Geonovum, 2019).

4   Conclusion and next steps

APIs are a general-purpose technology which has long been part of the ICT infrastructure in government organisations. However, the coordination of API resources in governments is as yet in an early adoption stage. Without API coordination, digital governments will miss opportunities to innovate, to improve government processes and operations, to assess robustness of its digital infrastructure and also to streamline information flows towards policymaking.

In this context, this work proposes a framework, developed within a European Commission study on API adoption in governments, to help governments to define a collaborative cross-agency API strategy. The framework is derived from the analysis of extensive literature about API adoption in organisations and the feedback obtained from experts and government API practitioners across Europe and globally. These sources acknowledge APIs as an enabling technology that facilitates data sharing, new digital product development, sustainable use and reuse of resources, and acts as a core lever for introducing emergent technologies such as artificial intelligence and the internet of things. To achieve these goals, organisations define API strategies to harness the transformative potential that API-enabled systems confer in a coordinated manner.

The framework was validated through a specific pilot run with the ICT directorate of the region of Lombardy (Italy), in charge of the coordination of the regional ICT infrastructure and by ARIA, a public company under the direction and coordination of the region. The framework has then been used by the regional government to update its 3 years' ICT plan, that now includes further actions, suggested by the outcomes of the framework proposals, to adopt API in government.

This framework has been developed to ensure it is sufficiently flexible to be used in different governments and also at different digital maturity stages. Specifically, the framework organises the process to achieve a whole-of-government API vision into 12 action proposals. These proposals represent a coordinated suite of activities and include indication at strategic, tactical and operational actions for the: (i) alignment of API adoption with policy goals, (ii) creation of platforms and ecosystem based on APIs, (iii) organisation of teams and development of an API culture, and (iv) design of processes based on API best practices. The description, importance, implementation and related additional documental resources of each proposal have been extensively detailed in the report.

Further tools and resources to support the adoption of the framework could help both the analysis and the implementation of a cohesive government API strategy. They include the following:

— Tools to support analysis of policy implications, including stakeholder network maps, impact assessments and policy alignment guides that help digital government leads to recognise where API opportunities exist;

— Activities and material to raise awareness of decision-makers understanding the value of APIs in digital government activities;

— Training resources to help build a public service with skills in ecosystem facilitation, collaboration, data sharing, user-centred design, and evidence-based value metrics;

— Technical guidelines to aid implementation including discoverability, documentation and licensing tools and API lifecycle design software and automated tooling;

— Alongside the development of resources, a platform that fosters a community of practice amongst government API stakeholders would also be valuable.

List of abbreviations

ADMS	Asset Description Metadata Schema
AI	Artificial Intelligence
API	Application Programming Interface
APIs4DGov	Application Programming Interfaces for Digital Government
BaaS	Backend as a Service
CEF	Connecting Europe Facility
CI	Continuous Integration
CIO	Chief Information Officer
CPSV	Core Public Services Vocabulary
CPSV-AP	Core Public Services Vocabulary — Application Profile
CTO	Chief Technical Officer
DCAT-AP	data catalogue application profile
DG	Directorate-General
DSM	Digital Single Market
eID	electronic identification
EIF	European Interoperability Framework
ENISA	European Union Agency for Cybersecurity
ERP	Enterprise Resource Planning
EU	European Union
EULF	European Union Location Framework
FaaS	Function as a Service
FHIR	Fast Healthcare Interoperability Standard
FIWARE	Future Internet Ware
GaaP	Government as a Platform
GDPR	General Data Protection Regulation
HATEOAS	Hypermedia As The Engine Of Application State
HL7	Health Level seven international
HTTP	HyperText Transfer Protocol

ICT	Information and Communications Technology
INSPIRE	Infrastructure for Spatial Information in Europe
IoT	Internet of Things
ISA/ISA2	Interoperability Solutions for public Administrations, businesses and citizens
ISO	International Organization for Standardization
JLA	JoinUp Licensing Assistant
JRC	Joint Research Centre
KPI	key Performance Indicator
MASA	Meshed App and Service Architecture
ML	Machine Learning
OAS	OpenAPI Specification
OASIS	Advancing Open Standards for the Information Society
OECD	Organisation for Economic Co-operation and Development
OGC	Open Geospatial Consortium
OOP	Once Only Principle
OAS	Open State Foundation
PSD	payment services directive
PSD2	second payment services directive
PSI directive	Public Sector Information directive
REST	Representational State Transfer
RPC	Remote Procedure Call
RTS	Regulatory Technical Standards
SDK	Software Development Kit
SLA	Service-Level Agreement
SOA	Service-Oriented Architecture
SOAP	Simple Object Access Protocol
SPDX	Software Package Data Exchange
TOOP project	the Once-Only Principle project

UNEP   United Nations Environment Program

XML   extensible markup language

W3C   World Wide Web Consortium

WoT   Web of Things

WSDL   Web Service Description Language

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References

6Aika, 'Working together towards open data business', 2017a (https://www.databusiness.fi/content/uploads/2017/10/20171106_WorkingTogetherTowards_WEB.pdf) (accessed 29 November 2018).

6Aika, 'API toolkit', 2017b (https://6aika.fi/wp-content/uploads/2017/11/20171102_APItoolkit_WEB.pdf).

6Aika, 'Guidelines and best practices for development of APIs and apps', 2017c (https://github.com/6aika/development_guide) (accessed 7 February 2020).

6Aika, 'Harmonised smart city APIs', 2017d (https://6aika.fi/wp-content/uploads/2017/11/20171109_HarmonisedSmartCityAPIs_WEB.pdf) (accessed 7 February 2020).

6Aika, 'Open API recommendations for cities', 2019a (https://6aika.fi/en/open-api-recommendations-for-cities/) (accessed 7 February 2020).

6Aika, 'Smart cities work together', 2019b (https://6aika.fi/in-english/) (accessed 14 April 2019).

ABS-MAS, 'Finance-as-a-Service: API Playbook', 2013 (https://abs.org.sg/docs/library/abs-api-playbook.pdf) (accessed 31 July 2019).

Agenzia per l'Italia digitale, 'Piano triennale 2019-2021', 2019 (https://www.agid.gov.it/it/agenzia/piano-triennale) (accessed 30 July 2019).

Amarelis, P., 'French API strategy', 2018 (https://ec.europa.eu/jrc/sites/jrcsh/files/18_04_patrick-amarelis_france.pdf) (accessed 4 May 2020).

Atos, 'Realizing the promise of government-as-a-platform', 2018 (https://atos.net/content/mini-sites/look-out-2020/assets/pdf/ATOS_LOOK%20OUT_GOVERNMENT.pdf) (accessed 12 March 2019).

Australian Government, 'About the digital service standard', 2019 (https://www.dta.gov.au/help-and-advice/about-digital-service-standard) (accessed 4 March 2020).

Axelos, 'ITIL® V3 foundational course glossary', Axelos, 2011 (https://itil.it.utah.edu/downloads/ITILV3_Glossary.pdf).

Belgium Government, 'REST Guidelines', 2020 (https://www.gcloud.belgium.be/rest/) (accessed 27 February 2019).

Boyd, M., '2015: API deprecation and versioning now a more strategic issue', 2016 (https://www.programmableweb.com/news/2015-api-deprecation-and-versioning-now-more-strategic-issue/analysis/2016/01/04) (accessed 27 September 2019).

Boyd, M. and Vaccari, L., *API best practice documents relevant to governments: comprehensive literature review*, European Commission, Joint Research Centre (JRC), 2020 [Dataset], PID: http://data.europa.eu/89h/7340ab8a-ef73-459b-a2d9-b64e1a5bb680.

Boyd, M., Vaccari, L., Posada, M. and Gattwinkel, D., 'API framework self-assessment maturity tool for governments', 2020 (https://ec.europa.eu/eusurvey/runner/APIFrameworkTool) (accessed 4 July 2020).

Broad, E., Smith, A. and Wells, P., 'ODI ethical data handling', The ODI, 2017 (https://www.scribd.com/document/358778144/ODI-Ethical-Data-Handling-2017-09-13) (accessed 27 April 2020).

Chaplin, J. and Roberts, M., *What Is Serverless?*, O'Reilly Media, Inc., Sebastopol, CA, 2017 (https://www.oreilly.com/library/view/what-is-serverless/9781491984178/) (accessed 7 July 2019).

Choudary, S.P., 'How digital platforms increase inequality', 2019 (http://platformed.info/how-digital-platforms-increase-inequality/) (accessed 4 May 2020).

CITADEL H2020 project, 'DIGIMAT – eGovernment maturity assessment', 2018 (https://www.citadel-h2020.eu/news/digimat-%E2%80%93-egovernment-maturity-assessment) (accessed 4 March 2020).

Danish Ministry of Finance, 'World-class Digital service', 2018 (https://en.digst.dk/media/18772/world-class-digital-service.pdf) (accessed 4 May 2020).

Danish Steering Committee for Data and Architecture, 'The digitally coherent public sector', 2017 (https://arkitektur.digst.dk/sites/default/files/white_paper_on_a_common_public-sector_digital_architecture_pdfa.pdf) (accessed 4 May 2020).

Dastur, Z., 'Digital transformation in government best practices', 2018 (https://lucep.com/digital-transformation-in-government-best-practices/) (accessed 13 May 2019).

Deakin, M. and Waer, H.A., 'From intelligent to smart cities', *Intelligent Buildings International*, Vol. 3, No 3, 2011, pp. 140–152.

Definition.net, 'Definition.net', 2019 (https://www.definition.net/privacy-policy) (accessed 14 April 2019).

Deloitte, 'API imperative: From IT concern to business mandate', *Tech trends 2018*, Deloitte Insights, 2018, pp. 111–131 (https://www2.deloitte.com/insights/us/en/focus/tech-trends/2018/api-program-strategy.html) (accessed 19 March 2018).

Digital Transformation Agency, 'Objective 2 — You will have seamlessly integrated services that support your needs and life events', 2019 (https://www.dta.gov.au/digital-transformation-strategy/digital-transformation-strategy-dashboard/objective-2-you-will-have-seamlessly-integrated-services-support-your-needs-and-life-events) (accessed 14 February 2020).

Erhardt, G.D., Roy, S., Cooper, D., Sana, B., Chen, M. and Castiglione, J., 'Do transportation network companies decrease or increase congestion?', *Science Advances*, Vol. 5, No 5, 2019.

Estonian Presidency of the Council of the EU, 'Ministerial Declaration on eGovernment – the Tallinn Declaration', 2017 (https://ec.europa.eu/digital-single-market/en/news/ministerial-declaration-egovernment-tallinn-declaration) (accessed 15 January 2020).

European Commission, 'A vision for public services', 2013 (http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=3179) (accessed 5 September 2017).

European Commission, 'eGovernment action plan steering board', 2016a (https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3438&NewSearch=1&NewSearch=1) (accessed 29 January 2020).

European Commission, *Towards faster implementation and uptake of open government: final report.*, 2016b (https://publications.europa.eu/en/publication-detail/-/publication/1071fdcc-aa45-11e6-aab7-01aa75ed71a1/language-en/format-PDF) (accessed 7 September 2017).

European Commission, 'Better regulation guidelines: Tool 13 (how to undertake a proportionate impact assessment)', 2017a (https://ec.europa.eu/info/files/better-regulation-toolbox-13_en) (accessed 27 April 2020).

European Commission, 'The new European interoperability framework (EIF)', 2017b (https://ec.europa.eu/isa2/eif_en) (accessed 12 March 2019).

European Commission, 'ICT Impact Assessment Guidelines', 2017c (https://ec.europa.eu/isa2/sites/isa/files/ict_impact_assessment_guidelines.pdf) (accessed 18 April 2019).

European Commission, 'Improving the use of API in digital government', 2018a (https://ec.europa.eu/digital-single-market/en/news/improving-use-api-digital-government) (accessed 10 July 2019).

European Commission, Communication from the Commission to the Commission – European Commission Digital Strategy, a digitally transformed, user-focused and data-driven Commission, COM/2018/7118, 2018b (https://ec.europa.eu/transparency/regdoc/rep/3/2016/EN/C-2016-6626-F1-EN-MAIN.PDF).

European Commission, 'APIs4DGov study workshop: Assessing government API strategies across the EU', 2018c (https://ec.europa.eu/jrc/en/event/workshop/assessing-government-api-strategies-across-eu) (accessed 13 March 2019).

European Commission, 'Summary report of the consultation on the review of the directive on the reuse of public sector information', 2018d (https://ec.europa.eu/digital-single-market/en/news/summary-report-consultation-review-directive-re-use-public-sector-information) (accessed 29 April 2020).

European Commission, 'EIRA v3.0.0 overview', 2019a (https://joinup.ec.europa.eu/solution/eira/distribution/eira-v300-overview) (accessed 15 April 2019).

European Commission, *APIs for CPSV-AP based Catalogue of Services*, 2019b (https://joinup.ec.europa.eu/sites/default/files/news/2019-09/ISA2_APIs%20for%20CPSV-AP%20based%20Catalogue%20of%20Services.pdf) (accessed 16 September 2019).

European Commission, 'Interoperability academy', 2019c (https://joinup.ec.europa.eu/solution/interoperability-academy/about) (accessed 19 February 2020).

European Commission, 'JoinUp Licensing Assistant (JLA)', 2019d (https://joinup.ec.europa.eu/collection/eupl/joinup-licensing-assistant-jla) (accessed 22 July 2019).

European Commission, 'European Union Location Framework (EULF) blueprint', 2019e (https://joinup.ec.europa.eu/collection/european-union-location-framework-eulf/eulf-blueprint) (accessed 23 February 2018).

European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions – A European strategy for data, COM/2020/66, 2020a (https://ec.europa.eu/info/sites/info/files/communication-european-strategy-data-19feb2020_en.pdf).

European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions - A new industrial strategy for Europe, COM/2020/102, 2020b (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0102).

European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions – An SME Strategy for a sustainable and digital Europe, COM/2020/103, 2020c (https://ec.europa.eu/info/sites/info/files/communication-sme-strategy-march-2020_en.pdf).

European Commission, 'Core vocabularies', 2020d (https://joinup.ec.europa.eu/collection/semantic-interoperability-community-semic/core-vocabularies) (accessed 19 February 2020).

European Commission, 'Support Centre for Data Sharing', 2020e (https://eudatasharing.eu/homepage) (accessed 12 August 2019).

European Commission, 'Licensing assistant', 2020f (https://www.europeandataportal.eu/en/training/licensing-assistant) (accessed 20 March 2020).

European Commission, 'CEF Building Blocks', 2020g (https://ec.europa.eu/cefdigital/wiki/cefdigital/wiki/display/CEFDIGITAL/Building+Blocks) (accessed 3 April 2019).

European Commission, 'Machine translation for public administrations – eTranslation', 2020h (https://ec.europa.eu/info/resources-partners/machine-translation-public-administrations-etranslation_en) (accessed 27 March 2020).

European Union, Directive (EU) 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), OJ L 108, 2007, pp. 1–14 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02007L0002-20190626).

European Union, Commission delegated regulation (EU) of 29.11.2018 supplementing Directive (EU) 2015/2366 of the European Parliament and of the Council with regard to regulatory technical standards setting technical requirements on development, operation and maintenance of the electronic central register within the field of payment services and on access to the information contained therein, OJ L 73/84, 2018, pp. 1–9 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0411&from=EN).

European Union, Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the reuse of public sector information, OJ L 172, 2019, pp. 56–83 (http://data.europa.eu/eli/dir/2019/1024/oj/eng).

Fielding, R.T., Architectural Styles and the Design of Network-based Software Architectures, University of California, Irvine, CA, doctoral thesis, 2000 (https://www.ics.uci.edu/~fielding/pubs/dissertation/fielding_dissertation.pdf) (accessed 3 April 2019).

Fielding, R.T. and Reschke, J., 'IETF RFC 7230: Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing', 2014 (https://tools.ietf.org/html/rfc7230) (accessed 22 July 2019).

Finland Ministry of Finance, 'Enterprise architecture in public administration', 2018 (https://vm.fi/en/enterprise-architecture-in-public-sector) (accessed 4 May 2020).

Finnerty, B., 'A Digital Government Technology Platform Is Essential to Government Transformation', 2018 (https://www.gartner.com/doc/3848267/digital-government-technology-platform-essential) (accessed 19 March 2019).

French Secretary-General for the Modernisation of the Public Action, 'L'écosystème numérique', 2019 (http://etatplateforme.modernisation.gouv.fr/ecosysteme-numerique) (accessed 4 May 2020).

French Secretary-General for the Modernisation of the Public Action, 'State Platform', 2020 (http://etatplateforme.modernisation.gouv.fr/etat-plateforme-territoire-numerique) (accessed 18 February 2020).

Fujitsu, 'Government as a Platform', 2015 (https://www.fujitsu.com/uk/Images/government-as-a-platform.pdf) (accessed 12 March 2019).

Gartner, 'From APIs to Ecosystems: API Economy Best Practices for Building a Digital Platform', 2019 (https://www.gartner.com/doc/reprints?id=1-693RZYX&ct=190219&st=sb) (accessed 1 April 2019).

Geonovum, 'API strategie voor de Nederlandse overheid', 2019 (https://docs.geostandaarden.nl/api/vv-hr-API-Strategie-20190715/) (accessed 7 February 2020).

GeSI, D., 'GeSI facilitates real world solutions to real world issues within the ICT industry and the greater sustainability community.', 2020 (http://gesi.org/platforms) (accessed 4 May 2020).

Ghazawneh, A. and Henfridsson, O., 'Balancing platform control and external contribution in third-party development: the boundary resources model', *Information Systems Journal*, Vol. 23, No 2, 2013, pp. 173–192.

Google, 'Apigee - the complete guide to API products', 2019 (https://pages.apigee.com/apis-products-register.html) (accessed 4 June 2018).

Government of Canada, 'Standards on APIs', 2019 (https://www.canada.ca/en/government/publicservice/modernizing/government-canada-standards-apis.html) (accessed 11 January 2019).

Government of France (DINSIC/DINUM), 'Détail des 9 principes clés', 2020 (https://references.modernisation.gouv.fr/detail-des-9-principes-cles) (accessed 14 February 2020).

Government of Massachusetts, 'The growing carbon footprint of ride-hailing in Massachusetts', 2019 (https://www.mapc.org/wp-content/uploads/2019/07/Growing-Carbon-Footprint-of-Ride-hailing-in-MA.pdf) (accessed 5 March 2020).

Government of New Zealand, 'API standard and guidelines', 2016 (https://www.digital.govt.nz/standards-and-guidance/technology-and-architecture/application-programming-interfaces-apis/) (accessed 1 February 2019).

Government of south Australia, 'Digital strategy toolkit', 2019 (https://www.dpc.sa.gov.au/__data/assets/pdf_file/0010/46567/Digital_Maturity_Assessment.pdf) (accessed 4 March 2020).

IBM, 'Authorization', 2014a (https://www.ibm.com/support/knowledgecenter/en/SSFKSJ_9.0.0/com.ibm.mq.sec.doc/q009750_.htm) (accessed 26 March 2019).

IBM, 'What is a web service?', 2014b (https://www.ibm.com/support/knowledgecenter/en/SSGMCP_5.3.0/com.ibm.cics.ts.webservices.doc/concepts/dfhws_definition.html) (accessed 3 April 2019).

IEEE, 'IEEE standard computer dictionary: A compilation of IEEE standard computer glossaries', *IEEE Std 610*, 1991, pp. 1–217.

IETF, 'Keywords for use in RFCs to Indicate requirement levels', 1997 (https://www.ietf.org/rfc/rfc2119.txt) (accessed 6 February 2020).

ISO/IEC/IEEE, 'ISO/IEC/IEEE 42010:2011(en), Systems and software engineering – Architecture description', 2011 (https://www.iso.org/obp/ui/fr/#iso:std:iso-iec-ieee:42010:ed-1:v1:en) (accessed 19 March 2020).

Italian digital agency (AGID), 'Three year plan for the ICT in the public administration (2019 - 2021)', 2018 (https://docs.italia.it/italia/piano-triennale-ict/pianotriennale-ict-doc/it/2019-2021/index.html) (accessed 7 February 2020).

Iyengar, K., Khanna, S., Ramadath, S. and Stephens, D., 'What it really takes to capture the value of APIs (McKinsey)', 2019 (https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/what-it-really-takes-to-capture-the-value-of-apis) (accessed 14 January 2019).

Iyengar, K., Lau, L., Ramadath, S. and Sohoni, V., 'The seven make-or-break API challenges CIOs need to address', McKinsey, 2018 (https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-seven-make-or-break-api-challenges-cios-need-to-address) (accessed 7 February 2020).

Jacobson, D., Brail, G. and Woods, D., *APIs: A Strategy Guide*, O'Reilly Media, Inc., Sebastopol, CA, 2011 (http://shop.oreilly.com/product/0636920021223.do) (accessed 13 March 2019).

Jensen, D. and Campbell, J., 'The case for a digital ecosystem for the environment. Discussion paper: bringing together data, algorithms and insights for sustainable development', UNEP, 2018 (https://un-spbf.org/wp-content/uploads/2019/03/Digital-Ecosystem-final.pdf) (accessed 29 July 2019).

Karmel, A., Chandramouli, R. and Iorga, M., *NIST definition of microservices, application containers and system virtual machines*, NIST Special Publication 800-180 (Draft) No 180, National Institute of Standards and Technology, Gaithersburg, MD, 2016 (https://csrc.nist.gov/CSRC/media/Publications/sp/800-180/draft/documents/sp800-180_draft.pdf) (accessed 14 April 2019).

Kennan, A., 'How we're building great digital products inside government', 2018 (https://medium.com/nyc-opportunity/how-were-building-great-digital-products-inside-government-fd1c110a5a6) (accessed 16 April 2020).

Kivimaki, P., 'Two steps from X-Road REST support', 2019 (https://www.niis.org/blog/2019/3/25/two-steps-from-the-x-road-rest-support) (accessed 29 April 2020).

Koponen, J., 'Public sector platforms: a promising way forward for societies', 2018 (https://www.demoshelsinki.fi/en/2018/05/29/public-sector-platforms-a-promising-way-forward-for-societies/) (accessed 7 February 2020).

Kütt, A., 'API-first government', 2016 (https://www.slideshare.net/AndresKtt/api-first-government) (accessed 18 February 2020).

Lane, K., 'Some questions to ask when quantifying your organizational API maturity', 2019 (http://apievangelist.com/2019/09/19/some-questions-to-ask-when-quantifying-your-organizational-api-maturity/) (accessed 29 April 2020).

Lane, K., 'API-first [business]', 2020 (https://apievangelist.com/2020/03/10/apifirst-business/) (accessed 4 May 2020).

Lantmäteriet, *Swedish Spatial Data Infrastructure and the National Geodata Strategy.*, Lantmäteriet (the Swedish mapping, cadastral and land registration authority), 2017 (http://ggim.un.org/country-reports/documents/Sweden-2017-country-report.pdf).

Le, Q.T. and Pishva, D., 'Application of web scraping and Google API service to optimize convenience stores' distribution', in *2015 17th International Conference on Advanced Communication Technology (ICACT)*, 2015 17th International Conference on Advanced Communication Technology (ICACT), 2015, pp. 478–482.

Loosemore, T., 'Making government as a platform real', 2018 (https://public.digital/2018/09/25/making-government-as-a-platform-real/) (accessed 7 February 2020).

Margetts, H. and Naumann, A., *Government as a Platform: What can Estonia Show the World?*, Working Paper funded by the European Social Fund, 2017 (https://www.politics.ox.ac.uk/materials/publications/16061/government-as-a-platform.pdf) (accessed 18 September 2017).

McKendrick, J., 'The best API strategy is not to start with an API strategy', 2019 (https://www.zdnet.com/article/the-best-api-strategy-is-not-to-start-with-an-api-strategy/) (accessed 7 February 2020).

McKinsey, 'Cutting through the noise: How banks can unlock the potential of APIs', 2019 (https://www.mckinsey.com/industries/financial-services/our-insights/banking-matters/cutting-through-the-noise-how-banks-can-unlock-the-potential-of-apis) (accessed 7 February 2020).

Medjaoui, M., '5 ways an API is more than an "API"', 2014 (https://medium.com/@medjawii/5-ways-an-api-is-more-than-an-api-bddcdb0517ca) (accessed 7 February 2020).

Mehdi, M., Wilde, E., Mitra, R. and Amundsen, M., *Continuous API management: Making the right decisions in an evolving landscape*, O'Reilly Media, Inc., Sebastopol, CA, 2018 (https://www.oreilly.com/library/view/continuous-api-management/9781492043546/).

Negreiro, M., 'Bridging the digital divide in the EU', 2015 (https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/573884/EPRS_BRI(2015)573884_EN.pdf) (accessed 4 May 2020).

OASIS, 'Reference model for service-oriented architecture 1.0', 2006 (http://docs.oasis-open.org/soa-rm/v1.0/soa-rm.html) (accessed 3 April 2019).

OECD, 'Recommendation for Digital Government Strategies', 2014 (http://www.oecd.org/gov/digital-government/recommendation-on-digital-government-strategies.htm) (accessed 2 February 2019).

OECD, *Strengthening digital government*, OECD Going Digital Policy Note, OECD, Paris, 2019a (http://www.oecd.org/going-digital/strengthening-digital-government.pdf) (accessed 2 April 2019).

OECD, 'Unlocking the digital economy – A guide to implementing Application Programming Interfaces in government', 2019b (http://www.oecd.org/tax/forum-on-tax-administration/publications-and-products/unlocking-the-digital-economy-guide-to-implementing-application-programming-interfaces-in-government.pdf) (accessed 25 July 2019).

OGC, 'Glossary of terms – S', 2019 (https://www.opengeospatial.org/ogc/glossary/s) (accessed 8 April 2019).

O'Neill, D., 'US Government API performance dashboard', 2018 (https://apimetrics.io/apimetrics-free-api-tools-resources/check-api-health/us-government-api-performance-dashboard/) (accessed 5 March 2020).

Owyang, J., 'The difference between strategy and tactics', 2013 (http://www.web-strategist.com/blog/2013/01/14/the-difference-between-strategy-and-tactics/) (accessed 13 August 2019).

Panebianco, M., 'APIs and digital ecosystems in Lombardy', 2019 (https://www.slideshare.net/mpanebian/apis-and-digital-ecosystems-in-lombardy) (accessed 24 February 2020).

Papazoglou, M.P. and Georgakopoulos, D., 'Introduction: Service-oriented computing', *Communications of the ACM*, Vol. 46, No 10, 2003, pp. 24–28.

Pinzon, C., Renard, R. and O'Neill, G., *SC100_European Interoperability Framework (EIF) Implementation and governance models*, European Commission, 2019 (https://joinup.ec.europa.eu/sites/default/files/news/2019-04/D05.02_EIF_WorkshopReport_v3.00.pdf) (accessed 27 April 2020).

Piunno, S., 'New directions for interoperability in Italy', 2017 (https://ec.europa.eu/jrc/sites/jrcsh/files/17_08_simone-piunno_italy.pdf).

Polli, R., 'Interoperability rules for a European API ecosystem: Do we still need SOAP?', 2018 (https://speakerdeck.com/teamdigitale/interoperability-rules-for-an-european-api-ecosystem-do-we-still-need-soap) (accessed 15 April 2020).

Ramaprasad, A., Sánchez-Ortiz, A. and Syn, T., 'A unified definition of a smart city', in *Janssen, M., Axelsson, K., Glassey, O., Klievink, B., Krimmer, R., Lindgren, I., Parycek, P., Scholl, H. J. and Trutnev, D. (eds)*, Electronic Government: 16th IFIP WG 8.5 International Conference, EGOV 2017, St Petersburg, Russia, September 4-7, 2017, Proceedings, Cham, Switzerland, Springer, 2017, pp. 13–24.

Regione Lombardia, 'Il Programma regionale di sviluppo della XI legislatura', 2018 (https://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioRedazionale/istituzione/programma-e-finanze/programma-regionale-di-sviluppo/approvato_prs_xi_legislatura) (accessed 29 April 2020).

Regione Lombardia, 'E015', 2020 (https://www.e015.regione.lombardia.it/PE015) (accessed 24 February 2020).

Robinson, R., 'Beyond the baby? A vision for next-generation government technology', 2020 (https://complexdiscovery.com/beyond-the-baby-a-vision-for-next-generation-government-technology/) (accessed 15 April 2020).

Schema.org community, 'Schema.org', 2020 (https://schema.org/) (accessed 26 April 2020).

Shamsee, N., Klebanov, D., Fayed, H., Afrose, A. and Karakok, O., *CCNA data center DCICT 640-916 official cert guide*, Cisco Press, 2015.

Smart Nation Singapore, 'Moments of life initiative', 2020 (http://www.smartnation.sg/what-is-smart-nation/initiatives/Strategic-National-Projects/moments-of-life-initiative) (accessed 14 February 2020).

Swagger.io, 'What is API documentation, and why it matters?', 2019 (https://swagger.io/blog/api-documentation/what-is-api-documentation-and-why-it-matters/) (accessed 26 March 2019).

Swedish Governmental Agency for Innovation Systems, 'Swedish API license', 2020 (https://apilicens.se/en/) (accessed 25 February 2020).

Thomson, M., 'What is government as a platform and how do we achieve it?', 2015 (https://www.computerweekly.com/opinion/What-is-government-as-a-platform-and-how-do-we-achieve-it) (accessed 12 March 2019).

UK Department for Business, Energy & Industrial Strategy & Cabinet Office, 'Cyber security guiding principles', 2013 (https://www.gov.uk/government/publications/cyber-security-guiding-principles) (accessed 4 May 2020).

UK Government, 'Government technology and digital services', 2019a (https://www.gov.uk/government/government-technology-and-digital-services) (accessed 22 January 2019).

UK Government, 'Describing RESTful APIs with OpenAPI 3', 2019b (https://www.gov.uk/government/publications/recommended-open-standards-for-government/describing-restful-apis-with-openapi-3) (accessed 29 April 2020).

UK Government, 'How to document APIs', 2019c (https://www.gov.uk/guidance/how-to-document-apis) (accessed 29 April 2020).

US Congress, 'Foundations for evidence-based policymaking act of 2018', 2019 (https://www.congress.gov/bill/115th-congress/house-bill/4174/text) (accessed 4 May 2020).

US Digital Service, 'The digital services playbook', 2020 (https://playbook.cio.gov/) (accessed 4 March 2020).

US Government, 'Key privacy and security considerations for healthcare APIs', 2017 (https://www.healthit.gov/sites/default/files/privacy-security-api.pdf) (accessed 19 February 2019).

Vaher, K., 'Next generation digital government architecture', Government of Estonia, 2020 (https://urldefense.com/v3/__https://projektid.hitsa.ee/download/attachments/34120852/Next*20Generatio n*20Digital*20Government*20Architecture.pdf?version=1&modificationDate=1582268586780&api=v2__;JSUlJ Q!!DOxrgLBm!ViuLn28VcAGF-Y4rr9NSJ0Md2UIxAaZyeehu0YeYPq4qLyEBsHem3JP38cjwdM8Q0kNJliZ84Q$).

Varteva, A., 'The smart city API cook book is out!', 2016 (//www.citysdk.eu/the-smart-city-api-cook-book-is-out/) (accessed 1 August 2018).

Victorian Government, 'Information management governance guidelines', 2017 (http://www.vic.gov.au/information-management-policies-and-standards) (accessed 26 April 2020).

Victorian Government, 'Understand the API design principles – digital guide', 2019a (https://www.vic.gov.au/understand-our-api-design-principles) (accessed 19 February 2019).

Victorian Government, 'Policies and standards for government IT', 2019b (http://www.vic.gov.au/policies-standards-for-government-IT) (accessed 7 February 2020).

W3C, 'Web services architecture: W3C working group note 11 February 2004', 2004 (https://www.w3.org/TR/ws-arch/) (accessed 3 April 2019).

W3C, 'Mobile web application best practices', 2010 (https://www.w3.org/TR/mwabp/#webapp-defined) (accessed 19 April 2019).

Warren, M., 'Data architecture for the Government of Ireland', 2018 (https://ec.europa.eu/jrc/sites/jrcsh/files/17_06_mark-warren-ireland.pdf) (accessed 19 February 2020).

Wilde, E., 'API-first: The essence of digital transformation', 2019 (https://www.apiscene.io/api-business-models/api-first-the-essence-of-digital-transformation/) (accessed 4 May 2020).

Williams, M., *Digital Government Benchmark – API study*, Joint Research Centre (JRC), European Commission, Ispra (VA), Italy, 2018 (https://joinup.ec.europa.eu/document/digital-government-benchmark-api-study) (accessed 19 March 2019).

Wordreference.com, 'Dictionary of English', 2020 (https://www.wordreference.com) (accessed 19 March 2020).

World Bank, 'Privacy by design: current practices in Estonia, India, and Austria', 2018 (http://documents.worldbank.org/curated/en/546691543847931842/pdf/Privacy-by-Design-Current-Practices-in-Estonia-India-and-Austria.pdf) (accessed 18 February 2020).

Annex 1. Glossary

Application programming interface (API)	An API is 'The calls, subroutines, or software interrupts that comprise a documented interface so that an application program can use the services and functions of another application, operating system, network operating system, driver, or other lower-level software program' (Shnier, 1996).
API-first model approach	An API-first model is an approach in which the organisation reviews its goals and asks if an API is the best way to achieve each goal (McKendrick, 2019; Mehdi et al., 2018; Medjaoui, 2014). That is, an API-first is an approach in which the agency uses APIs as a principal means to pursue its objectives and engage with their stakeholders from the design phase (Lane, 2020; Wilde, 2019).
API gateway	HTTP enables the use of intermediaries to satisfy requests through a chain of connections. There are three common forms of HTTP intermediary: proxy, gateway and tunnel (Fielding and Reschke, 2014). An API gateway is a software component initially popular within the microservices world, but now also a key part of an HTTP-oriented serverless architecture. An API gateway's basic job is to be a web server that receives HTTP requests, routes the requests to a handler based on the route/path of the HTTP request, takes the response back from the handler and finally returns the response to the original client. An API gateway will typically do more than just this routing, also providing functionality for authentication and authorisation, request/response mapping, user throttling and more. Depending on the gateway features, API gateways are configured, rather than coded, which is useful for speeding up development, but care should be taken not to over use some features that might be more easily tested and maintained in code (Chaplin and Roberts, 2017).
API versioning	API versioning is one of the steps of an API lifecycle (Jacobson et al., 2011). There's no common agreement on the definition of API versioning. If, from one side, an API is the embodiment of a technical contract between a publisher and a developer and this contract should stay intact, on the other side, sometimes, there is the need to start with a completely new version. So, even if we have found that API versioning is 'The ability to change without rendering older versions of the same API inoperable' (Deloitte, 2018) or that 'Non-backward-compatible changes break the API (i.e. a new one has to be released, and consumers must migrate from the old to the new one)' (Mehdi et al., 2018), we could accept the fact that, in the life of an API, starting over with a new version that might not be fully backward compatible with an older version or that might make the older version deprecated is unavoidable. Thus, retiring an API is often an unacknowledged part of the API lifecycle (Boyd, 2016) and versioning is part of the API design lifecycle.
Architecture	Fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution (ISO/IEC/IEEE, 2011).
Authentication	Authentication is the ability to prove that a user or application is genuinely who that person or what that application claims to be (IBM, 2014a; ENISA, 2019; NIST, 2019.
Authorisation	Authorisation protects critical resources in a system by limiting access to only authorised users and their applications (IBM, 2014a).
Digital government	Digital government refers to the use of digital technologies, as an integrated part of governments' modernisation strategies, to create public value. It relies on a digital government ecosystem, comprising government actors, non-governmental organisations, businesses, citizens' associations and individuals, that supports the

production of and access to data, services and content through interactions with government (OECD, 2014).

Digital platform	A digital platform is a technology-enabled business model that creates value by facilitating exchanges between two or more interdependent groups. Most commonly, platforms bring together end users and producers to transact with each other (own elaboration).
Digital technologies	Digital technologies or ICT, include the internet, mobile technologies and devices, as well as data analytics used to improve the generation, collection, exchange, aggregation, combination, analysis, access, searchability and presentation of digital content, including for the development of services and apps (OECD, 2014).
Documentation/ definition (in API)	Documentation (or definition) is a technical content deliverable, containing instructions about how to effectively use and integrate with an API (Swagger.io, 2019).
eGovernment	This refers to the use by governments of ICT, particularly the internet, as a tool to achieve better government (OECD, 2014).
External API	An external API is an API that has been designed to be accessible outside an organisation, including by the wider population of web and mobile developers. This means that it may be used both by the developers inside the organisation that published the API and by any developers outside that organisation who may need to register for access to the interface (own elaboration).
Information technology (IT)	The use of technology for the storage, communication or processing of information. The technology typically includes computers, telecommunications, applications and other software. The information may include business data, voice, images, video, etc. Information technology is often used to support business processes through IT services (Axelos, 2011).
Infrastructure	The framework or features of a system or organisation (Wordreference.com, 2020).
Internal API	These APIs are generally used to facilitate the sharing of data and services between systems within an agency, avoiding the need for complex point-to-point integration. They are not visible to any person or body outside the agency and are generally in the domain of the IT department (Williams, 2018).
Interoperability	This is the capability to communicate, execute programs or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units (IEEE, 1991).
IT infrastructure	All of the hardware, software, networks, facilities, etc. that are required to develop, test, deliver, monitor, control or support IT services. The term IT infrastructure includes all of the information technology but not the associated people, processes and documentation (Axelos, 2011).
IT service	A service provided to one or more customers by an IT service provider. An IT service is based on the use of information technology and supports the customer's business processes. An IT service is made up from a combination of people, processes and technology and should be defined in a service level agreement (Axelos, 2011).
Legal interoperability	Each public administration contributing to the provision of a European public service works within its own national legal framework. Legal interoperability is about ensuring that organisations operating under different legal frameworks, policies and strategies are able to work together (European Commission, 2017b).

Microservice	A basic element that results from the architectural decomposition of an application's components into loosely coupled patterns consisting of self-contained services that communicate with each other using a standard communications protocol and a set of well-defined APIs, independent of any vendor, product or technology (Karmel et al., 2016).
Private API	See 'Internal API'.
Public API	See 'External API'.
Organisation	In general, 'Organisations' here means public administration units or any entity acting on their behalf, or EU institutions or bodies (European Commission, 2016b).
Organisational interoperability	This refers to the way in which public administrations align their business processes, responsibilities and expectations to achieve commonly agreed and mutually beneficial goals. In practice, organisational interoperability means documenting and integrating or aligning business processes and relevant information exchanged. Organisational interoperability also aims to meet the requirements of the user community by making services available, easily identifiable, accessible and user-focused (European Commission, 2017b).
Participation (in policymaking)	Participation in policymaking happens when governments open up governmental decision-making towards citizens, businesses, and public administrations to ensure an open process for participation with the aim at enhancing public value (European Commission, 2019a).
Public value	Public value refers to various benefits for society, which may vary according to the perspective or the actors, including the following: (i) goods or services that satisfy the needs and expectations of citizens and clients; (ii) production choices that meet citizen expectations of justice, fairness, efficiency and effectiveness; (iii) properly ordered and productive public institutions that reflect citizens' desires and preferences; (iv) fairness and efficiency of distribution; (v) legitimate use of resource to accomplish public purposes; and (vi) innovation and adaptability to changing preferences and demands (OECD, 2014).
Representational state transfer (REST)	A software architectural style that defines a set of constraints that restricts the roles/features of architectural elements and the allowed relationships among those elements within any architecture that conforms to REST (Fielding, 2000).
RESTful API	RESTful APIs are based on the REST architectural style (Fielding, 2000).
Semantic interoperability	Semantic interoperability ensures that the precise format and meaning of exchanged data and information are preserved and understood throughout exchanges between parties, in other words 'what is sent is what is understood'. In the EIF, semantic interoperability covers both semantic and syntactic aspects (European Commission, 2017b).
	— The semantic aspect refers to the meaning of data elements and the relationship between them. It includes developing vocabularies and schemata to describe data exchanges, and ensures that data elements are understood in the same way by all communicating parties.
	— The syntactic aspect refers to describing the exact format of the information to be exchanged in terms of grammar and format.
Service-oriented architecture	An application pattern where applications offer services to other applications by means of interfaces (European Commission, 2019a).

Smart city	There is no definitive explanation of a smart city because of the breadth of the technologies that can be incorporated into a city in order for it to be considered a smart city. From the definition given by Husam Al Waer and Mark Deakin in their research publication (Deakin and Waer, 2011), the factors that contribute to a city being classified as smart are:

— the application of a wide variety of digital and electronic technologies in the city and its communities;

— the application of ICT to enhance life and working environments in the region;

— the embedding of such ICT within government systems;

— the territorialisation of practices that bring the people and ICT together to foster innovation and enhance the knowledge that they offer.

For a more formal definition of the term see also (Ramaprasad et al., 2017).

Social value	This report uses the definition of 'social value' as the OECD definition of public value, that is, 'Public value refers to various benefits for society that may vary according to the perspective or the actors, including the following: 1. goods or services that satisfy the desires of citizens and clients; 2. production choices that meet citizen expectations of justice, fairness, efficiency and effectiveness; 3. properly ordered and productive public institutions that reflect citizens' desires and preferences; 4. fairness and efficiency of distribution; 5. legitimate use of resource to accomplish public purposes; and 6. innovation and adaptability to changing preferences and demands.'
Software development kit (SDK)	Typically, this is a set of software development tools that allows the creation of applications for a certain software package, software framework, hardware platform or computer system (Shamsee et al., 2015).
Standard	A standard is a document that specifies a technological area with a well-defined scope, usually by a formal standardisation body and process (OGC, 2019).
Technical specification	A document written by a consortium, vendor, or user that specifies a technological area with a well-defined scope, primarily for use by developers as a guide to implementation. A specification is not necessarily a formal standard (OGC, 2019).
Transparency	Refers to disclosing relevant documents and other information on government decision-making and government activity to the general public in a way that is relevant, accessible, timely, and accurate (European Commission, 2019a).
Value chain	The value chain itself describes the full range of activities that are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers and final disposal after use (own elaboration).
Web application	The term 'web application' refers to a web page or collection of web pages delivered over HTTP that use server-side or client-side processing (e.g. JavaScript) to provide an 'application-like' experience within a web browser. Web applications are distinct from simple web content in that they include locally executable elements of interactivity and persistent state (W3C, 2010).
Web API	Web APIs are APIs that are offered and consumed through the web. They deliver requests to the service provider, and then deliver the response back to the requestor, i.e. they are an interface for web applications, or applications that need to connect to each other via the internet to communicate (Definition.net, 2019).

Web service	Different definitions of web service exist. The W3C defines a web service as 'a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialisation in conjunction with other web-related standards' (W3C, 2004). This definition links the concept of a web service to a set of specific technologies (SOAP, WSDL). Others provide more generic definitions, e.g. in (IBM, 2014b) the authors state that a 'web service is a generic term for an interoperable machine-to-machine software function that is hosted at a network addressable location'. Papazoglou and Georgakopoulos (2003) define a web service as 'a specific kind of service that is identified by a URI, whose service description and transport utilise open internet standards'. These extend the W3C definitions by essentially defining a web service as a service that is offered over the web. The OASIS reference model for service-oriented architecture defines a service as 'a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description' (OASIS, 2006).
Web service interface (provided by a web service)	Web service interfaces are designed to offer access to high-level functionalities for end users (either humans or machines) (own elaboration).

Annex 2 Methodology

This annex gives an overview of the methodology used to:

— conduct the best practice literature review;

— develop the framework and proposals;

— draft self-assessment maturity instruments.

This annex illustrates in depth the methodology components shown in Figure 1. It first describes the method used to classify the documents. Then, it illustrates how the documents have been collected and distilled into a shortlist. Next it presents the gap analysis, the creation and the validation of the. Finally, it concludes with a discussion of the methodological limitations.

Classification of the documents

In our literature review, the documentation was ranked by robustness of evidence into the following three categories:

— **Best practices:** This term is used to describe those strategies, tactics and operational implementations that **have been proven to have worked across multiple governments.** They are also the main approaches that are being proposed in multiple guidelines around the globe and are thus representing the emerging common standards to planning and building APIs. In this review, the term 'best practice' most closely aligns with RFC 2119's use of the word 'MUST' (IETF, 1997).

— **Guidelines:** This term is used to describe those strategies, tactics and operational implementations that **have been applied by some governments but have limited evidence of efficacy (as yet),** or that represent some frontier approaches being taken by governments showing a more experimental innovation agenda based on existing best practices. Sometimes these approaches require further consideration around the environment in which they are to be implemented (whereas the best practices above are more applicable across the board). These approaches can be given considerable weight and are applicable in many government cases. In this review, the term 'guidelines' most closely aligns with RFC 2119's use of the word 'SHOULD' (IETF, 1997).

— **Recommendations:** This term is used to describe those strategies, tactics, and operational implementations that **are suggested or being tested by some governments, for which there is not yet strong evidence.** This term is also used for suggestions being proposed by industry that have not yet been applied or completely understood for the government context. These approaches represent frontier, experimental efforts. In this review, the term 'recommendations' most closely aligns with RFC 2119's use of the word 'MAY' (IETF, 1997).

In addition, each document was classified as to whether it was applicable at an API strategy, API tactical, or API implementation level. Many documents were able to be classified as applying to multiple layers and the most predominant layer discussed in the document was used to guide categorisation. The definitions and theoretical background explained below were used to categorise documents into strategic, tactical or implementation categories:

— **API strategies:** This term is used to describe activities that should be applied at a whole-of-government level. Applying approaches at the strategy level often provide direction for legal, cultural, organisational, and structural decision-making, and more often reflect decisions that may impact a longer timeframe. These approaches are often aimed at policymakers, ministers, and department heads.

— **API tactics:** This term is used to describe the activities that allocate resources to achieve the overall policy goals. This application level is often most relevant to a department within a government (national, regional, state and local), or to a coordinating body that is working across a government to ensure collaboration or joint agenda actions are carried out by multiple departments.

After a government has set a broad vision or set of goals, the management of an individual department (or cross-collaborative agency) is then responsible for allocating resources, structuring their department, and ensuring alignment (and reporting) on these whole-of-government strategic goals. IT departments, both across government and within each department, must also make decisions about the information and communication technologies (ICT) infrastructure and design. Tactical suggestions

provide direction for departmental leadership, and the departmental management team, and often reflect decisions that need to be made on a medium-term time horizon, such as the 3- to 4-year life of a departmental action plan. These suggestions often impact on resource allocation and priority setting, and are aimed at departmental and agency heads, programme heads, and CTO/CIOs of government departments.

Along with an understanding of the broad policy goals being pursued by governments, API strategy leaders will need to understand what are the government priorities, and which goals are imperative to be achieved first. This will help set API framework activities and assist with allocating appropriate resources. For governments commencing work on their API framework, the amount of work that needs to be done can seem overwhelming, so understanding broader government policy priorities helps set a more achievable work programme.

— **API operations:** This term is used to describe the best practices, guidelines, and recommendations that apply at an implementation level. This level is relevant to agency and programme managers, and their implementation teams; and cross-agency teams that may be managing APIs across multiple government departments. Operational suggestions provide direction for technical implementers and API product managers, and often reflect decisions that can be made immediately in the design and delivery of APIs. These suggestions are often technical, and are aimed at systems architects, software leads, project leads, product managers, developer leads, and developers.

Table 28 shows which considerations were used to guide categorisation of documents in each of the three levels, based on the above definitions.

Table 28. Characteristics of the API documents

	API strategies	API tactics	API operations
Purpose	Identifies clear broad goals and vision to advance society and community	Sets actionable targets to be achieved by allocating resources (time, people and budgets)	Implements actions to reach targets using best practices and available tools within available resources
Roles	Elected members of government and government administration management	Departmental managers, cross-collaborative agency heads and elected members of government with subject matter portfolio responsibilities	Specific domain experts and subject matter professionals
Accountability	Responsible to community via elected members of government to deliver on agreed and documented vision	Responsible to government administrative management and portfolio government representatives by reporting on key performance indicators to achieve targets	Responsible to administrative management by demonstrating implementation of subject area best practices to achieve outputs and outcomes that align with targets
Scope	The functioning of the whole of government and its responsibility to support society, community and the environment as well as relationships with other jurisdictions	The overall allocation of departmental resources to achieve targets described in an action plan	A subset of resources (time, personnel and budget) provided to implement allocated tasks
Duration	Longer term, from lifecycle of elected government representatives to up to 10-20 years in advance	Medium-term, usually the life of the current government cycle, such as 3-4 years	For immediate action, either currently being implemented or required as part of an defined annual work programme
Methods	Uses political debate, visioning exercises, community consultations, research, promotion	Uses strategic planning exercises, negotiations, budgeting, evaluation	Uses best practices, professional guidance, tools, processes, teams
Outputs	Vision statement, government goals and principles, commitments, outcome measurements	Action plan with key task areas and responsibilities defined, key performance indicators focused on outputs	Clear deliverables and implementation activities, tools, time, teams, output indicators

Source: JRC, own elaboration.

Collection of the documents

Documents for the literature review were collected from multiple sources:

— Referred documents at commencement of study

— Keyword search via search engine

— Ongoing referral of newly submitted publications.

Initially, a set of 152 documents, coming from the ongoing research activities of the APIs4DGov study (workshops, surveys, case studies), were included in the best practice literature review. From the analysis of these documents, a set of 39 keywords were chosen. These keywords were then used to perform a systematic web search to add further literature to the initial set of documents. Table 29 shows the list of the used keywords.

Table 29. Keywords used in literature review

Categories	Keywords	Total number of keywords
Location-specific terms	'[Member State/Country] Government API', where [Member State/Country] equals: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden Also: Argentina, Australia, New Zealand, Singapore, United States, United Kingdom.	27 7
API specific terms	Government API best practices Government API playbook Government API recommendations	3
Related terms	Government as a platform City as a platform	2
Total keywords		39

Source: JRC, own elaboration.

Keyword searches were conducted from 1 March-31 May 2019. The Google search engine was used, with location set to Brussels, Belgium. The first 100 searches for each keyword were collected using the Data Miner Chrome extension. Data Miner scraped the search results page by organising search results fields into a specific order. These results were then collated into as a CSV file by Data Miner and then imported into a spreadsheet.

Collected fields in the CSV included:

⎯ Title of content

⎯ URL link

⎯ Date of publication

⎯ Short description of content.

Each link in the spreadsheet was reviewed. An initial scan was conducted to remove any items that were clearly not relevant. For example, items related to active pharmaceutical ingredients and to advanced passenger information where removed (these are two other common API acronyms).

The remaining spreadsheet links were then opened, reviewed and assessed on the following criteria:

⎯ Is it after 2014?

⎯ Is government specifically mentioned? OR Is it relevant to a public sector audience?

⎯ Does it draw on actual experience of governments?

Items that could answer yes to each of these three criteria, were placed in a second spreadsheet. Those links were then read in depth.

A total of 968 articles were sourced in this way (including the 152 documents referred to the literature review from previous project components).

The 968 articles were then read. Many of them were duplicative, or not relevant to the best practices study. These were removed from the spreadsheet.

From this list, 343 articles were considered noteworthy and relevant to the study. This included 63 API guidelines that had been published globally specifically documenting the best practices that governments were already using to manage API-related activities. Figure 3 shows an overall summary of this process.

Figure 3. Literature review methodology document selection funnel

LITERATURE REVIEW METHODOLOGY

ONLINE SEARCH — 3,900 KW searches / 968 with API mention

343 articles on API best practices relevant to Government — RELEVANT ARTICLES

GUIDELINES — 63 government guidelines

74 Strategic / 41 Tactical / 55 Operational — BEST PRACTICES
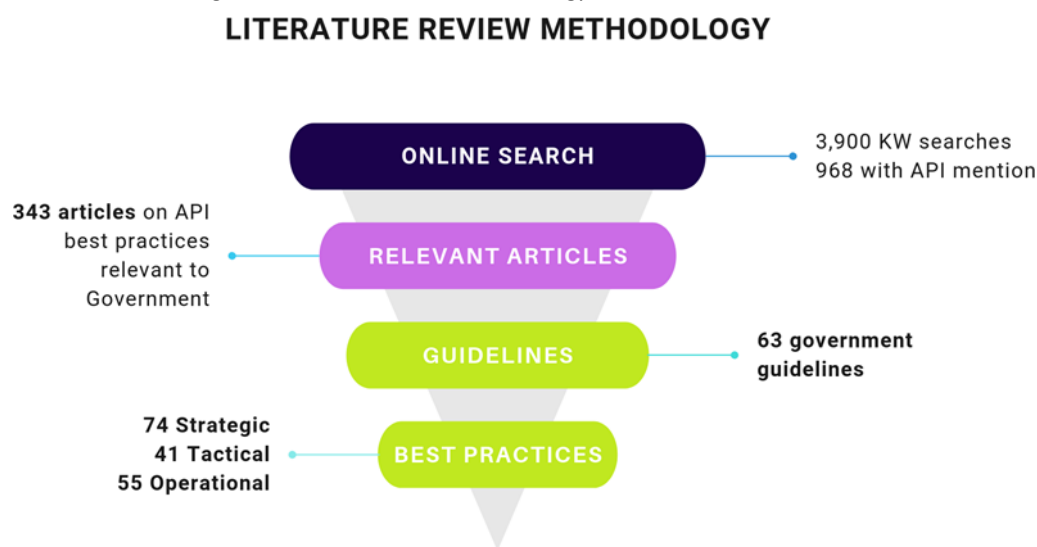
Source: JRC, own elaboration.

The 343 articles were collected onto a spreadsheet, with each document classified accordingly to the following rationale:

— **Location:** the country or the area where the document is to be applied

— **Author:** author of the document

— **Year:** year of publication

— **Title:** short description of the document

— **Link:** URL of the document

— **Topic:** specific field the document is about

— **Author type:** academic (university, research centre, etc.); consortium (or non-profit); expert (individual expert); international organisation; journalist; private company; public administration (government or other public institution)

— **Target sector:** intended audience of the document (public sector, private sector or both)

— **Target level:** (API) strategic, tactical (organisational), operational (implementation)

— **Area:** international, European, national, regional, city

— **Focus:** specific (specific document on APIs); general (general-purpose document, e.g. ICT strategy)

— **Document:** source of the document (government GitHub repository, official publication, commercial (private sector), vendor white paper, journal paper, presentation, blog, website)

— **Type:** best practice, recommendation, guideline.

The 343 documents were then re-read in order to commence the distillation methodology and added to the project's Zotero library of references.

In addition to these sourced documents, additional documents were also added during the framework drafting stage. These have been collected on a secondary spreadsheet. These documents were often newer and were referred directly to the project team, or were actively searched in order to address identified gaps during the framework drafting stage. It is envisaged that this secondary spreadsheet of documents will be added to the first

343 documents in follow-up project studies. New documents have also been sourced by converting the keywords used in the collection methodology into ongoing Talkwalker([13]) and Google alerts.

Literature review statistics

The majority of the literature reviewed, as shown in Figure 4, were official publications ([14]) (38 %) and blogs (24 %). There was a low number of academic journal papers included in the literature review (5 %). API strategy and design within the government is a new approach, with many practitioners still working on implementations. These actions are not yet giving rise to publication of peer-reviewed policy and implementation experiments. Government API practitioners tend to share their experiences and their reflections on implementation via blog posts and presentations. In this regard, the European Commission's APIs4DGov study has been instrumental in supporting the sector to provide briefings on government progress through the APIdays public sector tracks. The concerted focus on these events has allowed government API practitioners to describe their current context, indicate barriers and opportunities and share their implementation experiences.

Figure 4. Literature review by document type (N = 343)
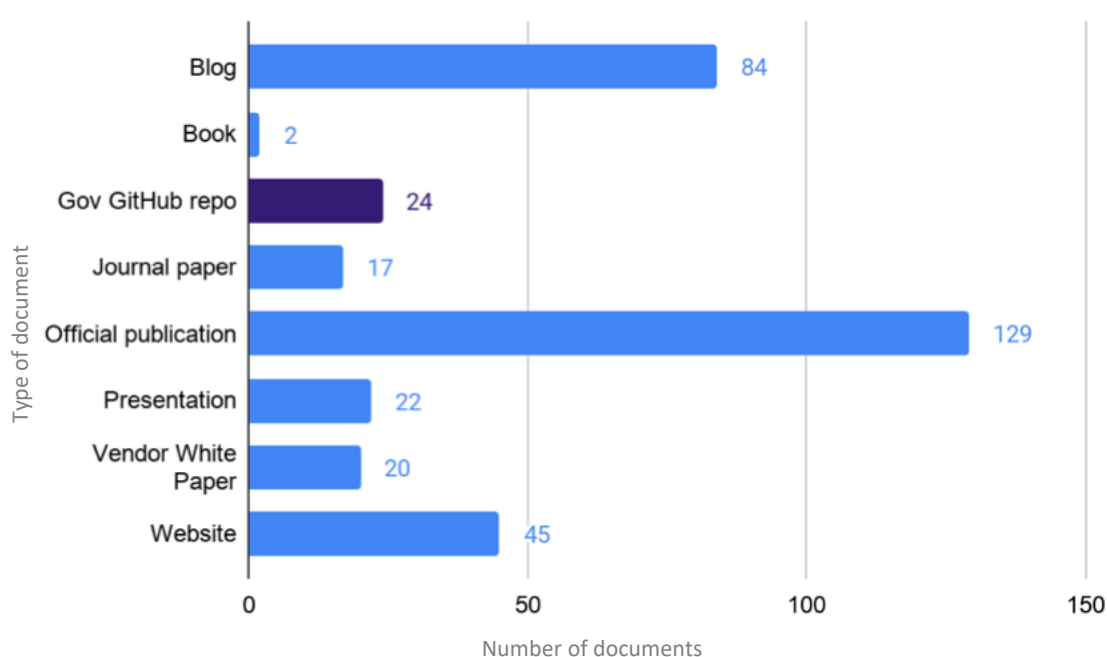
Source: JRC, own elaboration based on *(Boyd and Vaccari, 2020).*

One key trend evident from the types of literature reviewed was the growing number of GitHub repositories used by government to share their work. This now accounts for 7 % of all documents reviewed. While API style guides are the predominant type of document shared via GitHub by governments, other documents being shared on GitHub include overall API strategies, and design principles (for example, the Netherlands shares their API strategy via a GitHub-like repository, and the Government of Argentina share their design principles via GitHub). The use of GitHub, with the ability for external stakeholders to submit requests for new documents or to contribute themselves directly to documentation, indicates a willingness to encourage iterative development and engagement from external actors. This willingness is indicative of the uptake of both agile processes and ecosystem thinking.

From this, there was a fairly even spread of strength of evidence in these documents, based on the definitions described earlier in this document. As shown in Figure 5, 155 documents (45 %) were classified as including best

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([13]) Talkwalker is a service that provides daily updates of new content related to the keywords.

([14]) 'Official publications' refers to documents (often PDFs) that are published by the relevant government body or institution and made available on the web. The majority of 'official publications' are published and 'written' by government or a government department, e.g. 'Government of Argentina' or 'French Secretary-General for the Modernisation of the Public Action'. Other 'official publications' include OECD PDF reports and European Commission policies and legal documents such as, for example, directives.

practices, 103 documents were classified as guidelines (30 %) and 85 documents (25 %) were classified as recommendations.

Figure 5. Classification of documents in literature review categorised by robustness of evidence (N = 343)
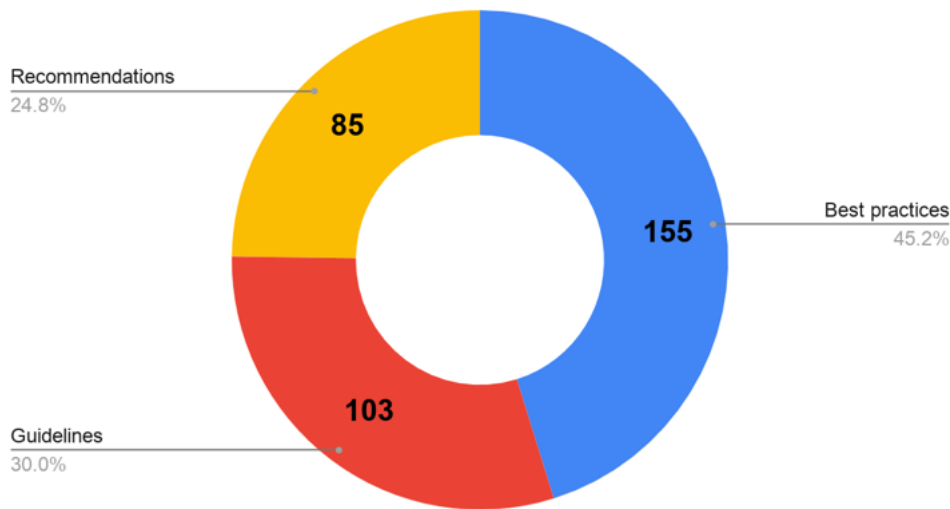
Source: JRC, own elaboration based on (Boyd and Vaccari, 2020).

While documents may have covered multiple topics, a single, predominant key topic was chosen to categorise each document. In Figure 6 below, the main topic covered by each document is categorised, with these then grouped into API strategy (purple), API tactical (orange) and API operational (teal). In the literature, there was the strongest consistency and evidence-based agreement on technical (operational and tactical) aspects of API implementation.

Figure 6. Main topics covered in literature review. Grouped by API strategy (purple), API tactical (orange) and API operational (teal) documents
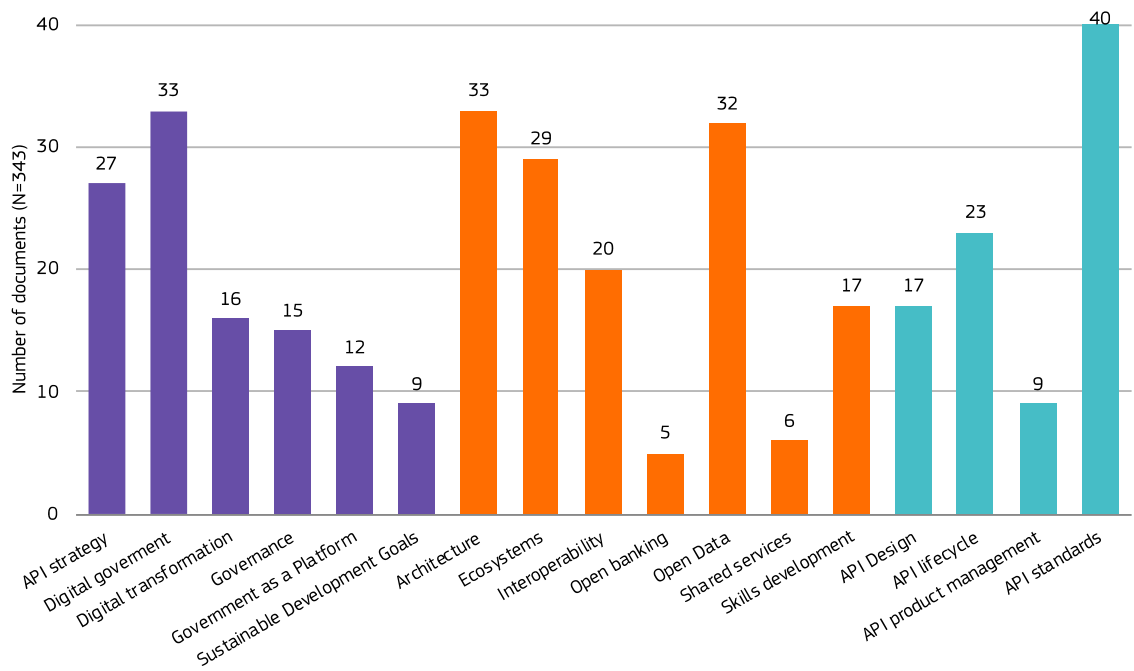
Source: JRC, own elaboration based on (Boyd and Vaccari, 2020).

The collection methodology lead to the creation of an open dataset published to the Joint Research Centre Data Catalogue (Boyd and Vaccari, 2020). This published open dataset includes a spreadsheet with links to articles and categorised using the descriptions outlined in the next section.

Distillation

All documents collected during the above process were re-read and key best practices from each document were analysed. These were added to a distillation dataset that was organised into three spreadsheets, one for each layer of application (strategic, tactical, and operational).

These spreadsheets included the following columns:

— **'Snippet':** A brief description or quote from the document that described the approach being taken.

— **Source:** URL Link back to the document.

— **Location:** Country or area field from collection spreadsheet.

— **Implementation notes:** Any specific considerations that would need to be taken into account when considering making recommendations on the approach, for example, whether it was a city government implementation and may have different implications at a national level.

— **Key themes:** Unstructured tags that were used as a summary to describe the general theme of the approach, for example 'governance'.

— **Robustness of evidence:** The approach was classified as either best practice, guideline or recommendation.

During this stage, key themes were not classified by any organising taxonomy. Instead, we allocated relevant tags reflecting the general theme of the approach.

Often articles would mention approaches that contained both strategic and tactical elements, or tactical and operational, for example. One article may be listed in multiple rows in the spreadsheet, depending on whether there were multiple best practice approaches to list, and whether they occurred at more than one application layer.

Following completion of analysis of all 343 documents and creation of the distillation spreadsheets, the themes were reviewed and organised into common categories. Categories covered policy-related approaches, those that reflected platform approaches, skills and capabilities needed by public service workers, and best practice processes. These category themes gave rise to the 'pillars' classifications of the API framework.

Within this literature review, we also identified a shortlist of documents from governments and private industry that are examples of best practices and approaches so that other governments can be inspired and learn from successful implementations. The following 12 documents were chosen as they met the above criteria and represented key evidence sources. These are recommended for review by any government stakeholder responsible for API implementations. Each of these documents walks through some basics of API benefits, through to implementation and management considerations.

Because they can be used by different target stakeholders, we tentatively classified documents into two categories: API strategies and API tactics and operations. We suggest, anyway, to read our review of all the documents, as many of them contain best practices, recommendations and guidelines at strategic, tactical and operational levels.

API strategic documents

The United Nations environment programme science business policy forum discussion paper: the case for a digital ecosystem for the environment (Jensen and Campbell, 2018). This discussion paper proposes a model for a digital ecosystem so that data and digital technologies can be at the centre of solving urgent challenges. Indeed the most important area of work that governments around the globe will need to address in the coming years is the threats from the climate crisis facing all world citizens, the environment and industry.

The paper proposes a digital environment ecosystem for data that includes data, infrastructure, algorithms and analytics, and insights and applications. APIs are recognised as one of the infrastructure components: 'a digital

ecosystem for the environment should also promote open data access and openness and standardisation of application programming interfaces (APIs), including data derived from citizen science'.

The discussion paper recognises that an important component of a digital ecosystem of environmental data will be the use of standardised APIs to enable data sharing. While APIs are acknowledged as an infrastructure component that enables access to data, in reality, APIs will be a glue that connects many of the ecosystem components. For example, algorithms and applications will need to be enabled via APIs.

This paper is a good start to explain some of the roles that APIs could play in harnessing collaboration and as a policy enabler, but the details limit the role of APIs to data transfer. Despite this, governments are acknowledging that APIs are a policy-enabling technology that can be used to meet climate challenges, such as the Swedish Country Report on Spatial Data Infrastructure and the National Geodata Strategy.

The **European Interoperability Framework (EIF)** is a commonly agreed approach for the delivery of European public services in an interoperable manner (European Commission, 2017b). Even if not specific for APIs, the EIF provides public administrations with a set of recommendations to improve governance of their interoperability activities, establish cross-organisational relationships and streamline processes supporting end-to-end digital services, and provides the means to ensure that existing and new legislation do not compromise interoperability efforts. In particular, according to the underlying principle of transparency, the recommendation is to 'ensure internal visibility and provide external interfaces for European public services'.

The European Commission: European Location Framework (EULF) blueprint (European Commission, 2019e) includes recommendations relevant to adopt APIs at the strategic and tactical levels. The document is shortlisted because it describes the complexity and need for governments to balance legacy infrastructures with new API-based technologies in a way that is not clearly described in much of the other literature.

The European Union's Location Framework blueprint outlines a number of recommendations to address the lack of interoperability and complex duplication of location data models and standards being used across Europe, which result in significant barriers to moving towards a digital government and a whole-of- government shared platform. This is highly relevant to operational leaders who are responsible for introducing API infrastructures into their government organisation. Recognising that some governments are operating with service-oriented architecture (SOA), while others have modernised towards a microservices approach, the blueprint outlines 19 recommendations that seek to enable the vision of a shared interoperable location data and government capabilities framework, rightly noting that geospatial and location data is an integral component in such systems as 'location information is key public data and much public policy has a location context'.

The blueprint outlines goals from a strategy level through tactical and down to operational. At the strategy level, the blueprint recommends integrating location information into all policy and whole-of-government strategies; leveraging open standards and data protection principles; using common data models that prioritise reuse of data; and create integrated governance structures that encourage partnerships across governments, and with industry and non-profits. The blueprint encourages 'adopting "Government as a Platform" (GaaP) approaches to share components, service designs, platforms, data and hosting across public authorities, enabling location data and services to be reused as effectively and widely as possible.' At a tactical level, the blueprint recommends modernising IT infrastructure while reusing technical solutions wherever possible, creating collaborative bodies, and building capabilities in location intelligence.

Most importantly, at an operational level, the blueprint recommends adopting a common architecture that enables interoperability and integration of location intelligence across government digital services. To achieve this, EULF Architecture and Standards for SDI and eGovernment have been defined, mostly based on service-oriented architecture. However, the blueprint also recommends: 'Consider deploying a Meshed App and Service Architecture (MASA) approach. This is a new application architecture structure with constituent parts (apps, mini services, microservices and mediated APIs) which delivers increased agility and enables application innovations to support internet of things (IoT) integration, automated decision-making, third-party interoperability and omni-channel business models. A mediated API is a design pattern in which an API is virtualised, managed, protected and enriched by a mediation layer. This layer can enforce policy and inject capabilities into the API interaction for increased agility, usability, performance, security and control. A mediated API allows a service to expose an 'inner API' that directly reflects its domain model, and one or more 'outer APIs' tailored to support specific client requirements.' The benefit of this approach is that APIs can then be exposed to third party providers to create an API marketplace and stimulate an API economy.

Industry analysts at **McKinsey and Company have worked with a wide range of large enterprises on reorienting their operations towards an API-first approach.** In (McKinsey, 2019; Iyengar et al., 2018), the authors acknowledge that while the European Union's second payment services directive has introduced compliance requiring banks to simplify legacy systems and provide access to ecosystems (via APIs), 'when it comes to API implementation, progress is patchy'. This is largely because most banks do not understand how to apply a data-driven business model (akin to how governments have not yet defined for themselves a common definition of 'government as a platform').

While these two articles focus predominantly on banks, the lessons are immediately transferable to government settings. Both articles describe the complexity and ad hoc API environments faced by government as much as banks and the importance of aligning API activities (and metrics) with business value. At present, most banks (91 %) surveyed by McKinsey focus on internal APIs (that is, to connect internal systems), with 7 % making APIs available to existing partners to link systems. According to McKinsey, only 2 % of banks offer open APIs aimed at fostering innovation through engaging with an external developer community. McKinsey suggests that for banks to take advantage for API benefits, they must focus on four elements: having a clear strategy; establishing API standards and a single technological platform; building internal team skills and capacity; and starting with a centralised team that can model best practice and then devolve to decentralised teams to pick up the pace.

A key underlying principle is that 'API development must be business-value focused'. The authors also note for reorientation to occur towards a digital banking approach (akin to reorienting towards digital government), it is best to start with a centralised team developing APIs and once a critical mass is reached, teams can decentralise so each line of business creates APIs, using the centralised teams examples as learning materials and internal standards. Funding strategies for lines of business would need to be changed as a result to recognise the work of the centralised team and the opportunities to reuse elements by lines of business teams.

In the second article, the authors also discuss how enterprises can get started ('prioritise API development based on the business's strategy, business impact, and ability to execute'); how to build teams (again, suggesting starting with centralised teams to build best practices and momentum), what to measure (direct business value of open APIs and reduction of technical debt of internal APIs), and the need to build a developer portal 'that serves as the front door for an organisation's API activities'.

National best practices and guidelines

In this section we comment (in alphabetic order) on relevant national API strategies gathered in our research. Once again, we suggest to read the review of all the documents, as many of them contain best practices, recommendations and guidelines at all the three levels (strategic, tactical and operational).

Canada: API Guidelines (Government of Canada, 2019).

The Canadian guidelines follow some of the lessons from New Zealand and are clearly inspired by the best practices from the UK. Unlike New Zealand, Canada's guidelines appear to be a living document and are guiding current government action. Canada has been able to create a single developer portal with meaningful APIs from across government departments that allow for third party partners to engage with government via API, while also using APIs as the architectural framework for delivery of the government's digital services.

The Canadian guidelines provide several bullet points to conceptualise API-first within an overall GaaP model (by explaining 'why APIs'), define the principles that oversee an API-first strategy (including design thinking processes), and then provide more detailed guidance for technical implementers on operational best practices and standardised approaches for all government departments.

This document presents best practice principles, often mirroring the UK API Design Guidelines, which outline technical best practices such as creating RESTful APIs, using appropriate authentication systems, and managing the full API lifecycle, from creation, through testing, deployment and managing APIs as products with documentation and support, ensuring discoverability, and providing appropriate licensing.

France: the French Connect system (presentation) (European Commission, 2018c).

The French Government's Prime Ministerial office has identified APIs as a core technical infrastructure to be used to achieve policy goals. This is managed by Dinsic, which acknowledges that government is a complex organisation (needing to connect with 36 000 municipalities, 101 departments, and 16 regions) and that 'APIs are everywhere'. Dinsic sees that what is needed is an approach in which trust is built between administrations (at national, regional and municipal levels) and between citizens and administrations. Central to building this

trust is offering a secure identity and authentication system as an API shared service where citizens can log in with their digital identity credentials and agree to share data or allow one system to access their data on another system in order to receive a service.

In addition, Dinsic has built a developer portal that publishes government APIs, with a goal of putting all government APIs into a single national catalogue. This also encourages each department to use existing APIs. France-Connect has become core to organisational data sharing. Buy-in has been built across government departments by using a five mechanisms model in which departments are encouraged to act through trigger, conduct, nudge, invest or lead strategies. API success across the government organisation is 'about changing the mindset in departmental organisations' says Dinsic.

This presentation demonstrates:

— the importance of leadership from the top;

— the role of a centralised team in modelling success;

— choosing a core shared service as the template for how departments should act;

— the importance of a common API catalogue;

— the need for a variety of buy-in strategies, in some cases mandatory insistence and in other cases via encouragement, modelling and providing investment resources to catalyse change.

Italy: the Italian 2019-2021 3-year plan for IT in the public administration (Italian digital agency (AGID), 2018). While technically this document is only available in English, using the European Commission eTranslation tool (European Commission, 2020h) allowed its inclusion as it is possibly the most cohesive, actionable, and fully conceptualised example of a government-wide API strategy that is based on a clearly articulated government-as-a-platform model. It is a strategic document, approved by the Italian Presidency of the Council of Ministers 'and has been signed by the President himself in recognition of the importance of the digital transformation of the country, that guides and supports the entire public administration in an organic and coherent process of digital transformation' (cit. from the, at that time, Italian Government Commissioner for the Digital Agenda, Diego Piacentini).

The plan defines how it is directed by, and aligns with, European-wide digital government policy initiatives (including the Digital Single Market strategy, the eGovernment Action plan 2016-2020, the Tallinn Declaration, the European Interoperability framework and the ISA$_2$ Interoperability Solutions for European Public Administrations programme) and sets stepwise goals with clear action statements for implementation at the national level. The plan identifies APIs as the key technology to deliver on the government's vision of government as a platform and extends this vision beyond the idea of a digitised, connected public administration to imagine what government engagement would look like in an ecosystem model with private industry actors, non-profits, research institutions and citizens leveraging APIs to create new values.

The methodical approach taken by the plan includes the following:

— The Italian Government maps its vision in a model showing various actors, both internally, at different administrative levels of government (both national and regional), and with private industry and the community.

— This map acknowledges the need to ensure common IT infrastructure, data models and interoperability mechanisms are in place.

— Following this, distinction is made between platforms and ecosystems. The government identifies a number of platforms. Platforms are defined as those common hubs each with a shared capability that enables work across multiple government departments (like identity and payments).

— In addition, 13 ecosystems are identified, with five given priority, that reflect common pools of stakeholders and represent key industries or fields where government will seek to leverage APIs to create new value via products and services delivered by third parties alongside government. The five priority ecosystems are public finance, development and sustainability, cultural heritage and tourism, welfare, and health.

A governance model is also described. It seeks to ensure the digital strategy is implemented in a timely way and to agreed standards but also includes roles to encourage capacity and skills building amongst actors and to

develop a monitoring and measurement framework to analyse and track progress, emerging best practices and unforeseen opportunities.

New Zealand: API Guidelines (Government of New Zealand, 2016) provide two documents at strategic/tactical (Part A) and operational (Part B) levels. The New Zealand guidelines demonstrate government best practices when it is possible to draw from the experiences of other international governments who have already commenced API strategies. These guidelines represent an underutilised option: the strategy harnessing an API approach seems to have been shelved, with these guidelines not updated since 2016.

The New Zealand guidelines are a useful read in that they clearly articulate a GaaP model in which APIs first create internal efficiencies and reduce duplication, are then expanded to offer the potential of delivering government services in new digital form, and finally enable integration with third party private providers who may then become partners in delivering new services and products to citizens and businesses. Following this strategic discussion of the benefits of APIs, the guidelines then go into some operational detail in setting best practices for the design and lifecycle management of government APIs.

These best practices follow other standard processes, notably those used by the UK government. Notably, the guidelines have a 'yet to be written' section documenting the governance processes that will oversee the creation and management of APIs across the whole of government as well as for individual department implementations. Perhaps the fact that this governance model was not established and able to steer the API strategy is why it has not gained traction since its initial publication. While this is disappointing, much of the strategy conceptualisation and operational guidance documented in the New Zealand guidelines reflect industry best practice today.

Singapore: Finance-as-a-Service. API playbook (ABS-MAS, 2013).

While focused on explaining how the Monetary Authority of Singapore is introducing APIs to regulate a national open banking platform, this document also provides a clear overview of how governments can identify opportunities to create APIs, and implement and manage them.

The document includes:

— A summary of the benefits of APIs for creating an ecosystem in which all stakeholders can participate;

— The process mapping approach used by Singapore's Monetary Authority to identify shared capabilities of the banking industry which led them to identify a suite of recommended APIs;

— A discussion on the importance of standardisation of APIs as a way to enable innovation and efficiency;

— A description of the levels of API governance required: at the government-wide/regulator level (to address risk, security and ensure alignment with government priorities), as well as at the API lifecycle level (to ensure standardisation of APIs to agreed internal and international best practices);

— A suggested API governance framework.

Following this introduction and overview, the bulk of the report then describes a set of APIs, and for each of them its use cases, and implementation considerations. For governments seeking to learn from this example, the overview section (the first 50 pages of the playbook) is the most valuable, while for those responsible for implementing an API as a product approach, the use cases may provide a model for their work.

The Netherlands: API strategy for the Netherlands Government (Geonovum, 2019). This excellent example of a national API strategy starts with acknowledging the ad hoc problem facing many governments when introducing APIs, data systems and shared services: 'With many government IT systems, the data is completely interwoven in the application. Every system has its own database and copies data to and from other systems. For example, many systems work at municipalities with copies of the national basic registrations. Over the years, this creates a maze of links between systems.' The goal, therefore, of a national API strategy is to unlock data and digital services in a reliable and secure way by using APIs.

The Netherlands strategy proposes departments start by conducting an inventory to map current APIs, data, and digital services within the government. The objective here is to identify duplication risks and highlight what data and services are used the most frequently and are therefore highest priority for API enablement. After these have been identified, departments (or sub-departments/teams) can identify users by creating personas, and then document the use cases for each persona.

The majority of the rest of the strategy is focused on sharing operational best practices and documenting internal standards such as API design guidelines and product management approaches (such as focusing on developer experience and ensuring licensing arrangements commit to performant, reliable API access). The strategy articulates the need for API teams to include a product manager who can ensure policy and use needs are aligned, an architect to oversee how the API will function consistently within a larger IT infrastructure and technical developers who will build the APIs.

The United Kingdom: 'Helping government use APIs better' (European Commission, 2018c) **and 'Making Government as a Platform real'** (Loosemore, 2018).

The first document is a presentation that the UK Government Digital Service (GDS) representative made at the APIs4DGov workshop on API EU strategies. The presentation defines the importance of setting API standards to avoid wasting resources and improve interoperability. The document contains a vision for the UK government API adoption based on the government transformation strategy of the GDS. The vision is implemented through the API standard project that aims to improve the collaboration across the public sector, allow the reuse of information and technology and share best practice use cases across the government.

The second document is an opinion piece from Tom Loosemore, one of the architects of the UK's GDS, where he worked as UK Government Deputy Director until 2015. The full literature review includes a large number of GDS documents, and the GDS is often used as a template for other nations. For example, the Canadian, New Zealand, United States and Victorian Government API guidelines all reference GDS examples. The OECD's API guidelines for tax systems was borne out of the leadership from UK GDS work. This piece was chosen because it provides a rare glimpse into the policymaking process within government and the cultural challenges that are faced, even by leaders who seem to have organisational reputational leverage to encourage change.

Loosemore defines a GaaP approach as one in which 'Government provides APIs, platforms, standards and data which not only improve public services, but which can also be relied on by a jurisdiction's private and third-party sectors. Government providing a solid, reliable suite of internet-era infrastructure on top of which both public and private value can flourish.'

He suggests that in practice this would mean government services could be delivered consistently, and in real time, with government departments able to set up new services in weeks and at a fraction of the cost of current processes. Ministers and policymakers would be able to see data to show the impacts of their decisions in a faster feedback cycle, and 'frontline staff' would be able to focus on those facing greatest inequalities and who had the greatest need. Services would 'work gracefully' across various jurisdictions, either within Europe or with other tiers of government. In Loosemore's vision, 'Everything should be available through an API for 3rd party use, provided it's secure and the user has granted consent.'

He suggests key early tasks for government include the following:

— Identifying common datasets that are used across various government departments be managed as single-source-of-truth data assets ('registries').

— Conducting process mapping to identify common functionalities that are performed across government departments and use these to create 'shared capabilities APIs'.

However, the biggest limitations that were seen by Loosemore in the UK's API implementation were that they did not create new cross-departmental collaborative bodies to imagine the new role of government in a platform model. As a result, some of the work being carried out by government resulted in merely replicating paper processes in a digital online environment rather than reflecting a new paradigm of what government can look like.

This piece is worth reviewing because it is one of the few documents in the literature that discusses failures in implementation. In particular, Loosemore reflects that those leaders advising government on APIs were 'not nearly bold enough' in defining a vision or executing on it.

Victoria: API Guidelines and related information management framework (Victorian Government, 2019a; Victorian Government, 2019b).

These documents were selected as they are some of the most recent examples of government API style guidelines and show how they fit into an overarching strategy framework. They draw on the proven experience of other jurisdictions such as the UK to describe strategy principles on information management that set

principles acknowledging customer-centred design, reuse of information and data, once only collection, and machine-readable, automated systems.

The information management framework makes clear recommendations for whole-of-government governance committees that are then supported by individual department governance committees so that policy, tactical and operational work maintains alignment.

The API Guidelines propose an API gateway so that all government departments and third-party partners can manage APIs through a common architecture, and also stipulate the creation of a single developer portal so that potential API users can discover all available APIs in one location. Style guidelines reflect industry and government best practices in API lifecycle management, API product management and use of technical principles including REST.

API tactical and operational documents

Finland: 6Aika best practices library (6Aika, 2019b; 6Aika, 2017d; 6Aika, 2017c; 6Aika, 2017b; 6Aika, 2017a).

Finland has seen a bottom-up, robustly tested approach to APIs emerge through city government strategies, and the learning from this model is shared in these documents. Six cities across Finland designed and implemented APIs for key city government functions:

— Realtime information-related APIs for events;

— Tourism information and government decision-making;

— An API to reserve government-owned facilities;

— An issue reporting API.

By building the APIs so that they were standardised across the six cities, the organising group (6Aika) was able to identify common best practices in the design and management of the APIs and these findings are shared in two summary documents. There is a higher likelihood that third party providers can build commercial applications to serve citizens and businesses if they are able to scale their applications by using harmonised APIs that work in multiple jurisdictions.

These reports set out some strategy-level recommendations, but in the main, they assume some decision has been made to pursue an API-first approach already. The reports:

— Propose core principles to guide governments in making APIs available (such as ensuring team skills and competence, creating appropriate management models, working across tiers of government, and using open standards and best practices);

— Provide guidance on harmonising data formats and data models;

— Explain how to create appropriate management structures;

— Describe how to implement an API lifecycle and product management approach;

— Explain licensing terms for APIs to encourage third party use.

These documents provide key best practices and guidelines for API management teams within government that are applicable at the local, state or national level.

New Zealand: API Guidelines (Government of New Zealand, 2016) provide two documents at strategic/tactical (part A) and operational (part B) levels. See the previous section for comments about these documents.

The OECD document: unlocking the digital economy. A guide to implementing Application Programming Interfaces in government (OECD, 2019b) acknowledges current technological processes and changes to the government service paradigm towards a model where economies are digitised, community ecosystems interact and deliver in partnership with government, and where 'tax just happens'. The authors note that 'our ability to create a world where "tax just happens" is increasingly dependent on "machine-to- machine" application programming interfaces (APIs)'. In a similar vein to the Singapore API playbook (ABS-MAS, 2013), a comprehensive overview is provided on 'Why APIs?' that defines a platform model for government that extends beyond the efficiency gains of reusability and reduction of duplication to innovation in government service delivery, and beyond to enabling new third-party partnerships delivered in new industry ecosystems.

While noting these strategic advantages of APIs, the report focuses predominantly on tactical and operational recommendations, including taking an API product management approach, and using best practices in API management. The report provides detailed recommendations on moving towards a common IT architecture that can enable an API-first tax management system for governments. These recommendations include building a common architecture that uses RESTful APIs, and utilising best practices in continuous delivery to modernise and future-proof IT systems.

Gap analysis

Drawing on the literature review findings, a SWOT analysis was performed to identify where evidence was decisive and where the evidence base did not provide sufficient guidance on what best practices to implement. A gap analysis was also conducted.

The literature review found some encouraging approaches that are beginning to highlight best practices or possible ways forward, overall. But the strategic context and ability to reorient organisational culture towards an API-first model within government is still relatively novel.

The available literature was not able to clarify:

— how APIs could align with broader policy goals of government;

— how government API activities would differ to private industry when not focused on for-profit motives, for example, when taking action aligned with the sustainable development goals;

— the appropriate infrastructure decisions regarding a centralised or common architecture approach and the adoption of REST APIs over legacy SOAP APIs;

— what barriers prevent greater adoption of user-centred and product management best practices within government.

Workshops were held to help resolve these gaps in the literature best practices.

At the APIdays conference in Helsinki (June 2019), a workshop hosted by the APIs4DGov study, was held with government and API stakeholders. Representatives included:

— Government API project leads;

— Statistics leads who had responsibility for whole-of-department API initiatives;

— Government IT architects;

— API design leads within government IT teams;

— Internet of things and CEF Building Block standards participants.

This workshop presented initial findings of the literature review and explored identified gaps in particular. Attendees noted the policy and cultural challenges facing government API implementations. The following comments were collected from the participants (based on their individual experience) and were grouped into three key challenges:

— **Awareness of topic:** 'There is little knowledge of digital platforms or APIs from the policymakers and decision-makers'; 'there is low awareness of the topic at decision-making level.'; 'Government doesn't currently get the concept of an API: there is a need to make evident the benefits'.

— **Cultural change:** 'It is difficult to change the culture and the traditional way of working'; 'Too many people think they could lose a lot if roles change substantially'; 'There is always a trade-off. Difficult to understand what can be achieved with innovation, and fear of showing ignorance'.

— **Incentivising funding:** 'There have been numerous pilot programmes funded, but these are not implemented as ongoing government approaches'; 'Funding for API and digital strategies is competing with funding for actual service delivery'; 'The funding model, funding in silos, or at best programme based, is done without considering the running costs and responsibilities once the service is operating'; 'Ministries work in silos and do not share knowledge, all offices are funded separately, no money for cooperation or reforming structure whereas companies can reform all the time. Sometimes funding mechanisms support the traditional workflows'.

The feedback from the workshop helped clarify the need to assist digital government and government API leaders to align their work with a wider policy context. The workshop helped clarify the four-pillars model and how it could be applied at the three application levels. The workshop also helped better guide discussions on governments' broader role and helped clarify the need to embed discussion on equity impacts of API adoption within a broader focus on identifying the value from APIs and using impact assessments. Similar discussions also helped reframe more opinionated recommendations on the API architectural structure that governments should follow to instead focus on the common platform and infrastructure elements that can be adopted depending on the government's particular structure.

A second workshop was held in Barcelona in September 2019, at the APIdays conference. The API framework was also presented in its entirety in a public sector track at this conference. This workshop focused on API implementations and the role of user-centred design. Key discoveries from this workshop that helped further develop this framework included:

— Recognition of the link between whole-of-government leadership as demonstrated by France in creating France Connect from the Prime Minister's office;

— Recognition of the importance of working with ecosystems from the French API-Agro model;

— The need to involve end users and leverage end-user needs to drive API standards, as demonstrated by Open State Foundation and the Netherlands Department of Statistics;

— The complexity and fragmentation that can develop when the European Commission does not stipulate 'API standards' as is the case with the second payments services directive, which created complexity for Member States in implementing national approaches, as described by Italy, and for fintech startups, as described by LUXHUB.

A final workshop was held in Paris in December at APIdays. This was held following a day of public sector presentations which saw more than 100 people in attendance throughout the day. The workshop presented all 12 proposals and these were discussed and further refined by participants. Proposed feedback was fairly minor and related to the definitions of particular statements and the need to show greater clarity on how the proposals work together and are interdependent. For example, participants requested greater clarity that the platform vision discussion in proposal 2 should flow into decision-making on platform and ecosystem components outlined in proposal 6, and be supported by operational actions in proposals 10, 11 and 12.

The workshops were the key outputs delivered to address the gap issues and analysis. Feedback from the workshops was reported back to the APIs4DGov project team and findings incorporated into the framework and proposals final draft.

Framework creation

Iterations of the framework were drafted following the distillation process described above. The literature informing initial drafts was then subjected to a gap analysis and the shortcomings were addressed through workshop activities and key informant interviews. This process drafted the initial set of 12 proposals, as illustrated in Table 30.

Table 30. Overview of how distillation of best practices influenced framework and proposal development

Proposal	Key source documents	Example governments implementing actions that reflect intent of the proposal	Strength of evidence
1: **Align APIs with policy goals**	OECD European Commission Better Regulation Toolbox Open Data Institute McKinsey	Australia (Victoria) France Italy Sweden	Medium
2: **Define the government platform vision**	Gartner OECD European Commission Interoperability Framework ATOS	Estonia France New Zealand Singapore	Medium

3: **Create governance structures**	European Commission Digital Strategy US Department of Veteran Affairs	Australia (Victoria) Belgium	Strong
4: **Form guiding principles for API processes**	OECD European Commission Tallinn Declaration Italy ICT Plan France Principles Guiding Modernisation	Canada France Italy UK	Strong
5: **Design metrics and prioritise APIs**	European Commission eGovernment Action Plan European Commission ICT Standardisation EC open data and public sector information directive US Digital Services Playbook	France Regione Lombardia (Italy)	Low
6: **Harmonise platform and ecosystems assets**	European Commission ISA2	Argentina Australia Canada Finland France Ireland Italy	High
7: **Establish cross-competency teams**	Private industry Suomi Digital Services Playbook 6Aika UK	Finland Italy UK	High
8: **Follow an API product approach**	Private industry API Evangelist	Canada Finland Netherlands Sweden	High
9: **Measure policy impacts of APIs**	European Commission Private industry Deloitte and GeSI UN Environment Program	European Commission	Low
10: **Build API platform components**	Mark Thompson Roberto Polli Denmark OECD UK Estonia paper	Australia (Victoria) Belgium Denmark Estonia Ireland Italy Netherlands UK	High
11: **Appoint API product manager(s) and teams**	6Aika Industry experts (Higginbotham & Casey; Medjaoui et al.) API Evangelist	Australia Canada Finland Italy Netherlands UK	High
12: **Adopt an API lifecycle approach**	6Aika Industry experts (Higginbotham & Casey; Medjaoui et al.)	Estonia Finland Italy Netherlands UK US	High

Framework validation

This API framework has been validated by a range of government and industry stakeholders who provided feedback on the clarity, appropriateness and relevance of the API framework's 12 proposals. Several additional requirements were highlighted and the final framework took these into account and was adapted accordingly.

The validation and the use of the framework was then tested in a pilot in collaboration with the government of Lombardia, Italy. Lombardia is the biggest (in terms of population more than 10 million citizens) and one of the most economic advanced regions in Europe. Representatives from the government and from the government's IT public authority with responsibility for overseeing digital government initiatives participated in a review of the 12 proposals and in the use of the self-assessment tool for six selected proposals. This process further validated the framework by giving an implementation example for the envisioned implementation scenario. This model was also discussed with key informants who provided further feedback and confirmed the model matched their current whole-of-government approaches to APIs.

In the case of the Regione Lombardia, a 3-year planning cycle is undertaken after the establishment of a new government. Internally, Regione Lombardia's IT Department leads on ensuring the infrastructure and APIs are in place and performant to carry out government operational activities. A public agency established by Regione Lombardia (ARIA spa), has responsibility for digital innovation and public procurement. Together, these two bodies steer the API strategy and ensure it aligns with the 3-year regional development programme of the 11th legislation, which outlines the regional strategic agenda (Regione Lombardia, 2018). As part of the government's plan, API activities are most closely aligned with a strategic pillar focused on digital transformation, and on work towards simplification of internal systems. Regione Lombardia is also a key participant in the Italian-wide 3-year IT Plans which seek to move towards API-enabled approaches. The Regione is also conversant with EU-wide interoperability and digital government goals and priorities.

Key strategic goals of government have been established and a final 3-year plan created and published. Individual departments then prepare action plans and budgets to ensure they have the necessary resources available to implement their strategic responsibilities. Broader action plans and budgets are flagged for the entirety of the plan, with each department required to submit a more detailed 1-year budget and action plan which must then be assessed and approved by the elected government of Lombardia. Similar processes are conducted by most regional and city governments in the EU.

The head of ARIA, equivalent to a digital government lead, worked with the region's IT lead to identify where APIs could help departments achieve their regional planning goals, and what infrastructure would be necessary to deliver on activities in a platform model (proposals 1, 5 and 6). The region had already established its platform vision through previous work on the E015 platform (Regione Lombardia, 2020) and the success of this published ecosystem was now reshaping how the government planned to create internal departmental platforms to encourage reuse of APIs and digital services internally and in specific domain ecosystems, as well as through the E015 platform (proposal 2).

As a main output of the piloting activities, the representatives of ARIA and Regione Lombardia identified:

— what actions would be necessary to support departments to implement API activities (proposal 1);

— the appropriate platform and ecosystem components they would need to build (proposal 6); and

— the necessary resources, budget, and tasks approval they would need to seek from the central planning oversight body (proposals 5-8).

Governance systems were in place already to provide oversight of API activities (proposal 3) but it was acknowledged that the operational processes of these governance structures needed to be further clarified during the next implementation cycle.

During the pilot Regione Lombardia was in the first quarter of its year's work programme to achieve the 3-year planning cycle goals. They were working on various activities that were identified as this year's priorities (proposal 5). This included new tasks such as supporting platform components for new ecosystems established by the broader planning process, which, in turn, included transport, healthcare and safety. They were also

working on developing materials to support those ecosystems and other departments to implement API best practices in line with proposals 8-12.

The valuable and generous contribution of Regione Lombardia allowed a thorough review of the draft self-assessment maturity checklists and edits were made as discussed during in-depth review sessions held throughout the pilot.

Methodology limitations

The methodology herein describes a comprehensive process that used a range of techniques to collect information, test assumptions, validate drafts, and confirm the final API framework and proposals. Future projects could be further enhanced to develop resources for governments moving towards API-enabled approaches. Three key limitations were identified throughout the project:

— **Research keyword as primary source collection:** In addition to a collection of source documents collected by the broader APIs4DGov team and provided at the start of the literature review process, keywords were the primary source used to identify relevant best practices. On reflection, while further keywords could have been chosen and tested prior to selection, future studies may consider using a more 'reverse engineered' approach to identifying best practice documents. In the broader APIs4Dgov study, a large number of government API cases were identified. An alternative methodology might be to start with those API use cases and then backtrack to identify how they were created, what policies guided their creation, whether there were any design documents that aided their development, etc. As the collection of API use cases was occurring during the literature review, this could not be done on this occasion, but more documents may surface for future similar research studies.

— **Platform communication with stakeholders:** The use of the APIdays conferences and the substantial work carried out by the APIs4DGov team to cultivate a community and encourage shared best practices amongst European government API leaders was essential to this project. It provided necessary validation opportunities and gave access to key informants that were able to provide clarification throughout the process. On reflection, the external expert assisting with the framework feels that he could have created another platform opportunity, either a webpage or a newsletter to share thoughts and findings during the process. Such an activity will be easier in future government APIs projects as there is now a body of work to discuss amongst practitioners (that is, the API standards report, Science for Policy Report, datasets on API government cases and best practices, and this API framework document). It will be difficult to build a community with stakeholders without assets to encourage discussion, but in future studies of this nature, it will be useful to have a platform and knowledge hub space and/or a regular newsletter to share with key stakeholders.

— **Maturity tooling:** During the drafting of the framework, it became clear that it would be beneficial to move beyond validation of the proposals. It was desirable to test how a government could assess their progress towards a maturity level in which the full intentions of the proposal were in place. The original literature review methodology did not include this task and fortunately, the APIs4DGov team was sufficiently adaptable and able to iterate during project progression to introduce this element. Future projects of this nature may consider incorporating pilot testing opportunities into any research creating sample resources for government APIs. It was also a key success of the project that an opportunity to pilot the checklists was generously provided by Regione Lombardia. Future projects may consider identifying a small group of governments at various levels (national, regional and city, as well as the European Union institutions) to test pilot resources.

Annex 3. Defining metrics that determine the success of API activities

Government APIs require ongoing allocation of resources and the maintenance of activities to ensure that they are achieving their intended value. Monitoring of the value APIs are generating is an important part of this ongoing maintenance. The European Commission's Better Regulation Toolbox notes that '*A monitoring system is a necessary and integral part of better regulation helping to:*

— *Identify whether a policy is being applied on the ground as expected*;

— *Address any implementation problems of an intervention*; and/or

— *Identify whether further action is required to ensure that it can achieve its intended objectives*.'

The Better Regulation Toolbox also suggests that a good monitoring system for a programme '*links objectives with their relevant indicators*:

— **Output indicators:** These relate to the specific deliverables of the intervention such as a new database for collecting monitoring results or a new European (CEN) standard, etc.

— **Outcome/result indicators:** These match the immediate effects of the intervention with particular reference to the direct addressees.

— **Impact indicators:** These relate to the intended outcome of the intervention in terms of impact on the wider economy/society beyond those directly affected by the intervention.

The monitoring system proposed in the European Commission's Better Regulation Toolbox can be used as a reference and adapted to create a relevant metrics system for government APIs. Below, we propose a set of possible indicators for each type of indicator identified by the toolbox.

Output indicators

Output indicators could measure the performance, uptime and stability of APIs. This includes best practice API lifecycle and product management indicators that are common for all API programmes whether they are from government or industry. The uptime (that is, stable availability) of an API, its performance, or the number of security upgrades enforced for an API may be examples of output indicators that could be measured. A dashboard to monitor API performances can also be used, such in the case of the US government APIs (O'Neill, 2018).

Output indicators that align with operational implementation may measure API lifecycle and product management concerns. This can include measuring the number of users/consumers of an API, the adoption rate, and the 'time to first hello world'. Best practices in API lifecycle and API product management offer many suggestions for these metrics (Varteva, 2016; 6Aika, 2017b).

Outcome indicators

Outcome indicators may measure the immediate value being generated by government API activities. Indicators could be in place to ensure APIs have the best chance of achieving success. For example, if weather data is released via API by a government, an outcome metric might be the number of live production cases where the weather API is being fed into an agricultural product to aid farm planning.

Outcome indicators may also measure the cost efficiency of APIs. Costs may be considered as economic, societal, or environmental impacts. It could be the case, for example that a government is seeking to take an API-first approach in which internal APIs are reused by multiple government services in order to increase efficiency and decrease duplication. In this case, an outcome metric might be the average number of government departments using an internal shared service API. Estimates might then be made on how much a government saves from each API reuse versus the costs incurred to a department when creating a similar API service.

Impact indicators

Impact indicators would relate APIs back to their intended policy goal. Here, the goal is to ensure that APIs are focused on the value they are intended to create. Mapping what policy goal is intended to be served by the API helps ensure 'policy alignment'. The weather API example given above can be extended to demonstrate a longer-term impact measurement. Governments could create a way to calculate the number of farms that are able to

increase production due to using digital products that use the government's weather API. Here, the true impact is being measured: Governments have introduced weather APIs to support the agricultural industry. This example metric aims to measure the amount of new production that can be attributed to the availability of the weather API.

Impact indicators can also be used to measure whether a government API is being delivered in a cohesive manner. This could include indicators on ensuring that the API programme is introducing the necessary supports to function as intended: The value an API is expected to create may take some time before its impact is measurable. Therefore, using indicators to measure whether the API is being supported by evidence-based, logical support resources can help ensure that potential future value is likely to be reached. For example, a longer-term goal of government might be to reduce CO_2 emissions by better enabling citizens and business to plan their travels and logistics sustainably. This would require a number of new digital products and services developed by the market that enable citizens and businesses to better plan transport and logistics. Using API and data model standards would help develop and scale products faster. Therefore, an indicator could measure the number of ecosystem partners that agree to use common API standards and data models for the transport industry.

Creating calculation methodologies to measure the value of government APIs

One of the limitations in introducing indicators for APIs is that underlying information is not easily identifiable and available to aid measurement. In private industry, metrics are often first built using calculations based on assumptions and measuring outputs, such as performance, number of accesses, number of apps, etc.

More challenging is the need to create calculations of the impact value that APIs are generating for government policy goals. For example, transport APIs can better support digital products (e.g. applications) to enable more seamless transport planning. This can reduce traffic congestion and in turn reduce air pollution. It can also increase a local area's sense of vitality by making it more enjoyable to move around a location without traffic obstacles or long public transport waiting times. It may also increase economic activity by encouraging more retail, venue visits, or other financial exchanges if transport is not a barrier to participation. But the contribution of APIs in enabling digital products that create these impacts is often unknown and difficult to quantify.

New models are needed to identify the economic, societal and environmental value that APIs are generating. Research is already being conducted to measure the impacts of tools and services that make use of private sector APIs. For example, ride-share services which use APIs to connect drivers with passengers are shown to increase both traffic congestion (Erhardt et al., 2019) and CO_2 emissions (Government of Massachusetts, 2019). Meanwhile, route planning digital products that use APIs have been proven to enable better business service delivery, reduce CO_2 emissions, and distribute goods and products more optimally (Le and Pishva, 2015). Further analysis of these studies (or similar ones) is required to calculate standardised weighted metrics.

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