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Christophe Gaie, Raul De Lacerda

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Ensuring project resilience and public services in a pandemic context: two French case studies

Christophe Gaie*

Centre Interministériel de Services Informatiques RH,
Paris, France
Email: christophe.gaie@gmail.com
*Corresponding author

Raul De Lacerda

L2S Laboratoire de Signaux et Systèmes – UMR CNRS 8506,
CentraleSupélec/Université Paris-Sud, France
Email: raul.delacerda@centralesupelec.fr

Abstract: This paper examines the resilience of IT projects to the COVID-19 pandemic. It provides a literature overview of resilience applicability in IT projects and it details the context of IT project management on public services. A simplified managed model is described to facilitate the evaluation of project resilience. This model enhances project resilience by strengthening the project in the organisational, operational, functional and project dimensions. Two case studies are detailed based on on-going IT projects carried by public French institutions: the modernisation of the French personal income system; and the migration of a full online teaching due to the sanitary confinement. The analysis realises the four dimensions and highlights their contribution in the pandemic recovery context. Whereas this approach may be perceived as simplistic, it offers essential lessons to improve resilience of IT projects for public services when facing unexpected crisis.

Keywords: IT project management; project planification; project resilience; public services.

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Biographical notes: Christophe Gaie is presently the Head of the Unit of IT Expert Services for the Ministry of Public Transformation (CISIRH). He previously worked for the Prime Minister and was Head of the team in charge of API Enterprise. He defended his PhD thesis on April 2010 in the domain of telecommunication.

Raul De Lacerda received his Dipl-Ing in Electrical Engineering and MSc in Teleinformatics Engineering from the Federal University of Ceará, Brazil, in 2003 and 2005, and MSc and PhD in Signal Processing from University of Nice-Sophia, Antipolis, France, in 2005 and 2008. From 2008 to 2009, he worked at the SUPELEC as a Research Fellow at the Alcatel-Lucent Chair on Flexible Radio and the Electromagnetism Department. Since 2009, he is an Assistant Professor at the SUPELEC.

1 Introduction

Computer science and information technology (IT) appeared and largely flourished by the end of the twentieth century. They became mandatory to ensure public policies such as education, public healthcare, homeland security, tax recovery, fraud detection, etc. Indeed, these technologies were introduced to modernise services, simplify, and accelerate procedures and reduce administrative expenses.

In the last decade, government states invested a large amount of money to modernise public services, as indicated by the level of the EU27 expenditure on general public services which reached 6.0% of gross to debt product in 2018 (Government Expenditure on General Public Services

– Statistics Explained, 2020). Thus, they expect to fulfil basic requirements like delays, costs, and quality [the well-known golden triangle (Gardiner and Stewart, 2000)]. Like in private organisations, project management thrives within IT departments and above. This explains the emergence of a culture of public IT project management inspired from the best practices of private companies.

The importance for project managers to possess solid skills in various aspects of project control (cost engineering, estimating, scheduling, budgeting, cost tracking and trending, etc.) was already strongly underlined in Zack (2004). A concrete experience of these skills, and not only an academic overview, grants managers an overstated certification. In the other hand, lack of experience could

provoke serious troubles when projects encounter unexpected situations, such as the COVID-19 pandemic, which results in undesired additional costs and delays.

Märhing (2002) proposed a summary of his PhD thesis which focus on organisational control of IT projects. The author addresses the involvement of the executive chain in different aspects of IT project control. The findings highlight that 'strong top management support' facilitates project dynamics (ostentation of complementary resources, project's priority level, etc.), but requires executives to have a good understanding of the operational chain, which can be a particular challenge. He concludes that reinforcement of horizontal and vertical communications seems to be the key to take advantage of mutual influence of top and middle management to improve project control.

A model to modernise critical and complex IT projects was proposed in Whitmore et al. (2008). The model is based on seven articulated sectors: work, new requirements, viability, productivity, scheduling, re-evaluation, and workforce. The behaviour of the model is analysed on the perspective of a study case, which corresponds to the modernisation of the IRS IT system. As expected, it shows that addition of unforeseen requirements during the project's lifecycle penalises it. They indicate that a moderate increase of training project's workforce as well as a complementary workforce, improve project success rate.

The fundamental causes of IT project failures were also examined in Al-Ahmad et al. (2009). The research extends the previous literature on this topic. Indeed, IT projects' failure is usually attributed to six factors: operational project management, hierarchical management (top-down management), technological challenges, organisation structure, complexity of objectives and processes. It is shown that this taxonomy may be combined with two dimensions: common factors of failure and specific causes. They illustrate their proposal by concrete example which facilitates the understanding of project risks, but they do not provide material to anticipate and avoid such risks.

As there are many causes that may prevent IT project success, researchers and managers sought opportunities to manage risks within projects and strengthen their capability to overcome sinisters. This explains the emergence of the concept of resilience within IT projects. There are multiple source of risks and threats that may impact projects: unexpected financial issues, human resources shortage, supply chain disruption, etc. Thus, ensuring resilience of projects does not simply require to focus on the development lifecycle but rather to setup a holistic approach.

The objective of the current paper is to provide a simple and efficient framework that offers better resilience, especially for IT projects in the context of public services. This aims to improve public service capability to cope with unexpected disasters (such as the current pandemic) and recover faster than before.

2 Literature review

A model based on IT-enabled enterprise risk management (ERM) was proposed Oh and Teo (2009) and relies on IT assets and organisational resilience. They show that their model improves organisation's ability to overcome risks. Their proof consists in providing a survey which describes 185 organisations in Singapore. They also deduct from their research that human aspects of risk management are equally important as tooling and measures to improve project resilience. Although the paper provides significant results on risk management, it does not detail concrete propositions to reduce it within projects.

Many models were also proposed to enhance the resilience of strategic cybersystems requires (Linkov et al., 2013). The resilience matrix (RM) proposed by Linkov combines four stages of the IT management cycle (plan, absorb, recover and adapt) and four domains of situational awareness and information decision-making (physical, information, cognitive and social). The matrix offers a very powerful capability to ensure that an organisation is mature in terms of resilience.

The role of risk management to ensure the success of IT projects was highlighted in Didraga (2013). The author provides a large review of the literature and analyses a large number of papers in the previous 25 years. Risk management is described through many aspects: risk management planning, risk identification, risk registration, risk analysis, etc. The author identifies measures proposed in the literature to manage these risks. The research also details the interview of 72 IT Romanian companies out of 361 interviewed. The author displays that only two techniques had an impact on the performance of IT projects: risk analysis and risk response monitoring. While this research details the prominence of some techniques to reduce risks, the author does not propose any concrete implementation.

Risk management also requires to make decision under uncertainty (Pich et al., 2002). In this objective, managers may activate three different project management strategies: instructionism, learning, and selectionism. Instructionism aims to reduce uncertainty and manage situations by defining contingent policies. On the contrary, learning aims to adjust to the observed situation, while selectionism respond to uncertainty by producing many offsprings. By modelling the complexity of the project with a payoff function, it is possible to select the relevant combination of strategies to efficiently manage projects.

Managing risks in complex projects requires to consider multiple layers (Thamhain, 2013). Three levels should be actively considered:

- 1 work process as they define the organisation functioning and efficiency
- 2 organisational environment as this knowledge facilitates the ability to cope with difficulties
- 3 people since the response is performed by workers of the organisation.

The research prove that simplicity, training and early detection of problems reduce the impacts of risks. This constitutes precursors to the concept of resilience management.

Then, researchers provided an analysis of project management standards as well as existing disaster recovery frameworks (Anthopoulos et al., 2013). Thus, the authors propose a model to cope with disasters. A wide survey shows the model efficiency for large amount of construction projects. The proposed model relies on different perspectives: integration, preparation, communications, recovery, legal and ethics, and quality. It may be easily adjusted to IT projects as the underlying principles are similar.

Afterwards, the importance of workforce diversity to improve productivity was highlighted (Saxena, 2014). First, the author provides a large review on the topic. Then, she details the advantages of diversified workforce. The author also considers the possible uncooperative behaviour of colleagues which shows the importance to manage efficiently human interactions to improve organisation productivity. In the current paper, we advocate that another interesting advantage of workforce diversity is to increase project resilience as pandemic often targets some specific segments of populations. In the meantime, some other workers may be less stricken.

There is also research which aim to take advantage of big data to improve crisis management (Emmanouil and Nikolaos 2015). Authors detail the four stages of big data operating: data generation, data acquisition, data storage, and data analytics. They detail the gathering of multiple data sources such as websites, geographical information systems, remote sensing, or social media. Another important dimension of the paper is the proposition to implement big data into different aspects of the crisis: prevention, preparedness, response, and recovery. This proposal establishes the stakes of preparing the project to ensure its resilience when a crisis appears.

Resilience assessment was modelled as a tiered approach with growing complexity and required data (Linkov et al., 2018). The tiered resilience approach integrates previous literature as tier I corresponds to simple systems where resilience relies on elementary toolboxes and simplified descriptions of vulnerabilities or threats on the system. Tier II approaches may include matrices of resilience as well as multi-criteria decision analysis whereas Tier III correspond to complex modelisations of the system that may require probabilistic computations. In light of the above, the current paper is identified as a tier II approach.

In the domain of economy, ensuring resilience reveals crucial to cope with disasters. It may rely on multiple factors such as capital, labour, infrastructure and materials (Dormady et al., 2019). The combination of these elements in a global framework enables to evaluate the resilience of an organisation and thereafter define a path to improve it through various tactics: conservation, resource isolation, input substitution, etc. This approach also develops theoretical foundations to optimise resilience tactics using

Lagrangian optimisation and Kuhn-Tucker conditions (Kuhn and Tucker, 1950).

The resilience of large organisations is intended to maintain critical functioning to cope with the various threats (Wood et al., 2018). It is possible to classify organisational resilience methods using a RM with event cycle phases (plan, absorb, recover, adapt) in the one side and context-specific resilience domains (physical, information, cognitive, and social) in the other side. This approach enables large organisations to identify rapidly improvement actions to implement. It also outlines potential redundancy that can be removed for better efficiency.

Furthermore, a definition of resilience based on an interdisciplinary perspective was proposed (Rahi, 2019). The author outlines the importance of awareness and adaptive capacity to achieve project resilience. A conceptual framework is proposed and illustrates the links between practices, risks and resilience. This article highlights the importance to identify known and unknown risks to manage them specifically. Whereas the proposal is interesting, there is no concrete implementation which could help IT project managers to improve their practices except general recommendations.

The combination of project management and resilience was recently broadened with multiple interdisciplinary dimensions (Naderpajouh et al., 2020). The proposed framework offers a multi-level approach with complementary perspectives: individual level, group, project, organisation, industry, and society. These perspectives may be iteratively integrated within IT projects to increase resilience or within research theory with operational declinations. In the current paper, the authors consider the individual, group, project and organisation perspectives and they also introduce a new functional dimension which corresponds to the features requested by the project sponsors.

A key contribution to research (Galaiti et al., 2021) details the difference between multiple concepts that characterise IT systems. In the current paper, the authors rely on the concept definitions by this paper. Indeed, the objective is to apply these concepts in the context of e-government in order to improve progressively governmental IT systems by:

- 1 enhancing the IT system sustainability to ensure a permanent high level of functioning
- 2 optimising IT robustness to reduce the damages in case of major disaster
- 3 developing the IT resilience that is to say the capacity to recover critical functions and adjust the system in case of a disruptive event.

The resilience of public services was also depicted in Drăgoicea et al. (2020) as the authors propose a four diamonds-of-context model for service design (entitled 4DocMod). The proposal provides a practical implementation of resilience based on four complementary perspectives: see, recognise, organise and do. The paper

underlines that resilience plays a decisive role to optimise a service. As a matter of fact, it enables teams to be pro-active, to develop and renew project resources and to explore new perspectives.

Ensuring the resilience of public services also requires ensuring ICT training of citizens (Chohan and Hu, 2020). As a matter of fact, training programs improve people's digital competency and facilitate the use of e-government applications. Interestingly, research also indicates that digital learning contributes to e-government adoption as well as a deeper improvement of procedures through redesign of processes. The findings of this paper are dedicated to citizens and should be extended to civil servants, especially those that ensure a proper functioning of e-government services.

The analysis of resilience during the COVID-19 pandemic was favourably analysed by taking account multiple dimensions including prevention (Coccia, 2021). The research proved that preparation was not the only criterion to cope with the pandemic. The efficiency of the governance (rapid decision making process) reveals really important such as preparedness through stress tests for example, as well as regular investment in the healthcare system. These lessons are immediately applicable in an IT context.

The importance of ensuring resilience arises in multiple contexts where IT disruptions become highly probable. The analysis of retail logistics provides many teachings in terms of preparation, potential causes, possible effects and troubleshooting processes (Klumpp and Loske, 2021). A key aspect of this research relies on the ability to measure the potential impacts of IT disruptions and optimise resource allocation to strengthen the system functioning.

Resilience is also a major concern in the context of cybersecurity (Hausken, 2020) with heterogeneous approaches and strategies depending on the type of actors concerned (organisations, individuals, threat actors, governments, insurers, etc.). Cyber resilience corresponds to the ability to react and ensure operational continuity when incidents occur. This reaction depends on multiple factors such as available resources, competences or tools. Cyber resilience may be improved through cyber insurance which transfers a risk to a third party. However, it may be irrelevant for strategic softwares and data.

An interesting approach of resilience consists in defining an indicator that evaluates the overall chain performance of a supply chain and facilitates decision making (Chen et al., 2020). This indicator may integrate different customer expectations in order to analyse the resilience when facing different needs. Interestingly the research outlines that in some situations, the introduction of supply chain resilience reveals useless. Although this research is worthwhile, it has to be completed with complementary dimensions such as risk management and system reliability.

Finally, the growing complexity of IT projects was outlined (Morcov et al., 2020) as well as the importance to provide solution to overcome it. The research provides a

valuable review on IT project management as well as additional suggestions to tackle the effects implied by IT project complexity. Thus, they propose innovative tools to analyse complexity and especially manage it. Whereas the proposal is attractive, it lacks from a case study to illustrate its applicability as well as its usage to maintain existing software.

In this paper, the authors provide a detailed framework to ensure that resilience is considered in IT project from their beginning to the software decommissioning. This framework relies on four cumulative dimensions to address as detailed in Section 3. Then, the paper illustrates in Section 4 and 5 the implementation of this proposal within two different IT projects. Finally, Section 6 details the contribution of the proposed framework to the literature and offers perspectives for further usage.

3 Forewarned is forearmed: a holistic approach

In this section the authors propose some guidelines to help IT team leader to prepare to unexpected situations. This relies on the long-standing principle illustrated by the Latin phrase '*praemonitus praemunitus*' (which means 'forewarned is forearmed'). The authors propose a holistic approach that aims to strengthen project management in each of its components and consequently ensure the system resilience.

The authors propose to consolidate the following project management dimensions by introducing a resilience perspective:

- *Organisation*: This dimension tackles the efficiency of working processes within the company, the association or the government service where the project takes place. Indeed, the resilience of a project depends on the capacity granted to managers to introduce new working practices; the ability of workers to adjust to a new situation and the possibility to adapt the rules to drastic change. The adaptability of an organisation is highly enhanced by the introduction agile management as it enables to adjust to stakeholders inconsistency as well as unexpected events (Rosenberg et al., 2017). Furthermore, the organisation should have a list of essential workers and ensure that a backup solution exists. Finally, the organisation should define how to manage a crisis in terms of hierarchy, mobilisation and decision process.
- *Operational*: This axis represents the intervention on existing applications. Assuredly, an organisation will be more resilient to the outbreak of a pandemic if only some specific operations require *in situ* interventions. These interventions should be anticipated and dedicated to identify staff members which are prepared to work in crisis conditions. There should be some usual intervention sheets to describe how to intervene on the system.

- **Functional:** This corresponds to the processes that structure the core functioning of the organisation. For instance, the Ministry of Education structured the functioning of schools, teaching, and examination through a Law of Education. Each educational institute has to fulfil the enclosed directives. Ensuring resilience requires possessing a precise inventory of the organisation processes. Moreover, providing simple procedures facilitates service continuity as deciders may understand it more easily and intervene faster if required.
- **Project:** This central dimension concerns the project itself and the capacity to pursue when a crisis appears. Assuredly, this ability is not innate and should be acquired by a specific preparation. The preparation should identify the possible effect of a crisis on the project roadmap, the available resources (human, material, financial, legal, ...) and possible adjustments of the projects in terms of calendar, scope, quality, etc. This anticipation should be adjusted continuously during the pandemic in order to provide a precise analysis of the situation and available scenarios. Finally, decisions should be made rapidly to mitigate risks or impacts on the project as expectation generates uncertainty and reduction of opportunities.

Figure 1 Triangle of dimensions to consider (see online version for colours)



Based on the literature presented on Section 1, it is observed that resilience under unexpected situations shall enhance by combining the following actions:

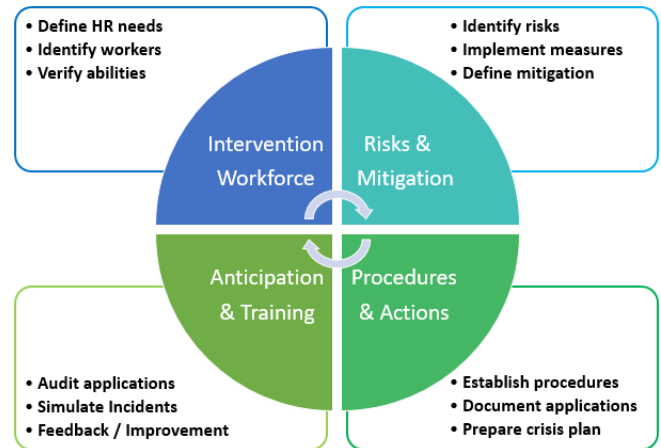
- 1 strengthen the organisation
- 2 ensure clear and efficient operational interventions
- 3 identify functional action-levers
- 4 manage the project in the crisis context.

The triangle of dimensions (see Figure 1) illustrates the actions within each of the considered axes to improve

resilience as well as their interactions. For instance, as the organisation is reinforced by human resources in terms of technical skills and adaptability, the functional dimension is enhanced by expertise and process simplification. Moreover, each time functional aspects are improved, the operational features are easier to implement and maintain.

To fulfil the publication length constraints, the authors decided to focus on the first two dimensions: organisation and project.

Figure 2 Actions to increase the efficiency of operational interventions (see online version for colours)



Another essential orientation to improve resilience consists in defining a set of actions which aim to increase the efficiency of operational interventions. Concrete measurements to ensure efficient interventions can be organised over four axes: risks identification, established procedures, staff training and intervention workforce. Figure 2 illustrates the actions to increase efficiency of operational interventions, and follows the subsequent principles:

- 1 *Intervention workforce* corresponds to the importance of anticipating the crisis situation and defining which staff members should be involved to resolve it. This preparation should consider every dimension of the crisis, that is to say do not neglect support team-mates.

Proposals:

- Define human resource requirements to solve the given type of crisis (number of workers, profile, abilities, experience, hierarchic level, age, risk factor, etc.).
 - Determine precisely who will intervene, where, when, and for which mission to avoid chaotic reactions.
 - Verify periodically the abilities of workers to adjust their missions considering their perspectives and their situations, which may evolve along time.
- 2 *Risks and mitigation* aims to identify the major risks for the organisation as well as its partners. It is also intended to define how to reduce these risks by mitigation measures and what are the residual hazards. This process enables reduce the potential impacts of a

crisis but also facilitate the crisis management as it provides a basis to build a response plan to the incident.

Proposals:

- Identify risks, order them by severity (i.e., combination of estimated probability and impact) to facilitate the crisis first analysis.
- Develop mitigation measures to reduce the risk probability or its impact.
- Define and validate acceptable levels of risk to set a clear limit between predictable and unpredictable situations.
- Evaluate periodically the risk framework to adjust it to new situations.

3 *Procedures and actions*, refers to the task of establishing procedures and actions which should be engaged in a crisis context. This action enables to reflect upon the different problems which can appear and provide a practical method to manage it. Although this reflection could be insufficient when a crisis is revealed, the upstream preparation contributes significantly to the ability of the organisation to fast react and mitigate the risks of a disaster.

Proposals:

- Prepare and establish a clear procedure for predictable situations enables to gather experience of crisis management situations.
- Document applications are crucial to ensure that the operations are able to install it, know the key parameters and perform common maintenance. This basic knowledge is necessary to solve a complex failover.
- Identify the successive steps to solve a crisis and define the roles and responsibilities of each involved actor.

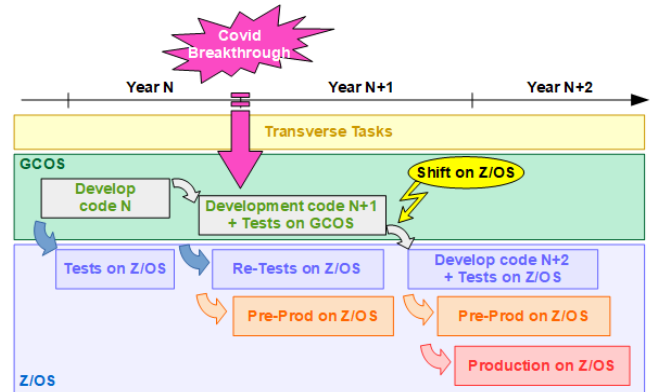
4 *Anticipation and training*, concerns the different measures to prevent abnormal situations. It also corresponds to the ability to manage it if they nevertheless occur. A comprehensive training requires taking advantage of each incident to improve its organisation, procedures, and emergency response.

Proposals:

- Ensure that applications are regularly audited by independent teams or contractors to obtain a fair judgement of its strengths and weaknesses.
- Organise a ‘bug bounty’ after deploying a new application but before opening it to new usages [see Rice et al. (2008) for a use case of this approach].
- Organise security exercises to ensure that the procedures are well known by every involved actor.
- Take advantage of the debriefing to improve the crisis processes, actor behaviours and response efficiency.

The current section provided a method to provide and measure resilience within IT projects. The two following sections detail this implementation through respectively the case study of the French personal income modernisation and the adjustment of teaching education in a French engineering school.

Figure 3 Impact of the pandemic on the project schedule (see online version for colours)



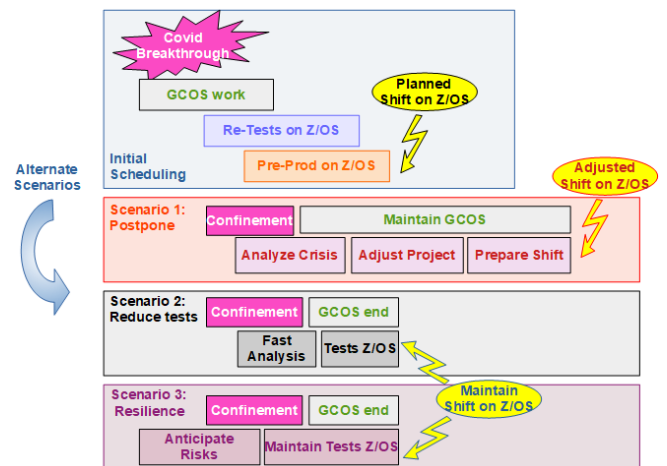
4 Case study: resilience of the French personal income modernisation

4.1 Identification of scenarios and choice

In Gaie and Barbier (2021), we detailed the modernisation of the French personal income system which relies on a COBOL legacy solution. The case study details the migration on modern mainframe platforms with juxtaposed open-source Linux.

The initial patrimony is tremendous in terms of code, scripts, parameters, etc. Moreover, there is an important effort of change management as experts have to follow specific training to cope with the new system while ensuring the functioning of legacy all along the modernisation process. Therefore, the project was scheduled in three years with additional workforce as detailed in Figure 4.

Figure 4 Illustration of available scenarios (see online version for colours)

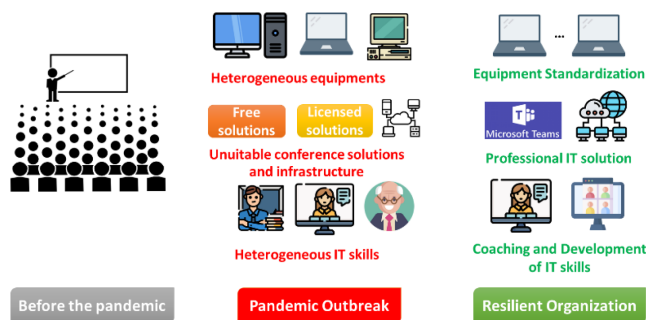


An unexpected event such as the COVID-19 breakthrough induces a potential crisis as it disturbs teams, work and priorities. In the following, we identify three possible scenarios which are detailed thereafter and illustrated on Figure 5:

- *Scenario 1 'postpone project'*, consists in delaying the project of one year to cope with the crisis effects and ensure that the tests remain exhaustive. This scenario maximises the ability to ensure the traditional legacy maintenance and preserve the whole capacity of testing the new platform. However this scenario reveals costly as it implies to pay for the former mainframe. Moreover, the additional workforce has to be paid an additional year or to be removed from the project with a risk too loose some expert skills.
- *Scenario 2 'reduce tests'*, refers to the project adjustment which maintains the production launch milestone. This scenario gives priority to the migration from the old system to the new one. This implies to run the risk of reducing tests which could generate program failures or incidents. The reliability of this scenario relies on the ratio of test reduction. If this ratio is limited to one-third of the initial allotted time, then this scenario remains reasonable. If the ratio is worst, then it would be very risky and the authors recommend to avoid it.
- *Scenario 3 'resilience'*, corresponds to the minimal adjustment of the project by taking advantage of a strong project preparation. As a matter of fact, a suitable anticipation relying on recommendations performed in the previous sections, enables to accelerate the crisis management duration. As a consequence, the time dedicated to test the project and finalise the migration, is almost completely maintained.

Coherently, the authors prescribe to follow the third scenario under the essential condition that the project was managed to enable it. On the contrary, the decision should depend on the duration and effects of confinement. If the duration of tests is reduced from less than a third, then the second scenario could be followed. On the contrary, the first scenario should be retained.

Figure 5 Evolution of CentraleSupélec organisation to ensure the resilience to the pandemic (see online version for colours)



4.2 Actions to perform in order to secure the project

The authors detail thereafter the different actions which should be achieved to ensure the project resilience in regard to the specific situation of the French Tax Administration.

4.2.1 Prepare and anticipate risks

The modernisation project is principally an organisation project. Indeed, the choice to migrate from an old mainframe technology to an up-to-date platform, requires a huge effort of scripts and code transformation, but does not require any specific ability. To avoid the appearance of functional problems on the existing IT system, a key principle was set: “the existing IT system is always a priority compared to the new one until the switch is fully performed.”

The project was precisely scheduled for three years and a long confinement period induces either an offset in the multiple test phases or a reduction of the validation phases (that is to say lower quality and higher risks). Each validation step aims to validate the functional conformity of the systems (ISO-functionality). As a consequence, the objective of the crisis response is to define a process which ensures limited impacts on the transformation validation phases in order to ensure the continuity of public services.

Another particularity of mainframe projects relies on the necessity for IT operational teams to access to machines. Thus, teleworking may be granted to IT developers and testers but not to every operation civil servant. Moreover, these workers also have to ensure the standard tax computation and recovery of year 2020. Thus, specific measures should be to facilitate the intervention of these production teams.

4.2.2 Strengthen organisation

The project organisation was depicted with strong governance with many levels of decisions. This corresponds to the usual functioning of the French Tax Administration which has to achieve multiple missions and major issues. However, this could be adjusted to particular situations and appropriate delegation of authority could be granted to intermediate hierarchy during the crisis phase.

The Tax Administration workforce has a strong experience of tax computation and recovery on mainframes. This provides a considerable asset during the crisis. As a matter of fact, their experience helps them to manage the regular tax campaign but may reduce their adaptability to cope with the modernisation itself. The introduction of a modular approach to develop the computation of the amount of personal income offers the possibility to priorities the developments with the highest functional value (some specific situations concerning very few tax payers could be modified later in the campaigning). Moreover, the presence of additional workforce composed of external engineers may provide additional adaptability to the project.

The French Tax Administration ensures that IT workers may organise their working day with extensive possibilities

in terms of personal time schedules. This organisation is really suitable to cope with unexpected situations. The proportion of civil servants with teleworking equipment provides an important measure on the organisation ability to adjust to a crisis situation. If this ratio was low at the beginning of the crisis, then it would be a top priority to equip the highest number of workers to increase the organisation adaptability.

4.2.3 Ensure efficient interventions

The success of the project largely relies on the capability to intervene on unpredictable situations. This requires identifying risks, set response procedures, ensure real-life testing and train the intervention workforce.

Like many wide organisations, the French Tax Administration is carefully prepared to many complex situations like flooding, building fire, cyber-attack (Secrétariat Général de la Défense et de la Sécurité Nationale, 2016), massive computer crash and even pandemic (Secrétariat Général de la Défense et de la Sécurité Nationale, 2011). Obviously, these situations are hardly testable and training may only be incomplete. However, the French Ministry of Finances had suffered from various damage and designed a specific activity continuation plan.

Another key asset of the French Tax Administration relies on the continuous improvement of mainframe procedures which exist from more than four decades. As the modernisation project consists in re-hosting the code, the common drawbacks of an old stratified code are not relevant. As a matter of fact, the novelty comes from the modified code which has to be deeply tested before confirming the migration.

Finally, the project will have to overcome the difficulty to fulfil the human resources requirements of every involved team. As the organisation is wide, this implies that no team will suffer specifically from the pandemic. This requires back-up every critical team-mate and ensuring that no cluster will appear. Simple solutions would be to set a basic personal planning where backup mates will never meet.

5 Case study: resilience of teaching education at a French engineering school (CentraleSupélec)

5.1 Identification of scenarios and choice

As the French personal income system, the high-education institutions suffered profoundly reorganisation to maintain its activities during the COVID-19 crisis. To illustrate the actions in terms of the proposed framework, this case study focuses on the actions carried on by a French engineering school to ensure their teaching activities during since the beginning of the first French confinement. The teaching activity migrated to a full online system, which relied on a project that was still being initially tested for very punctually and specific occasions.

Online courses are a rapidly growing mode of educational provision since the appearance of massive open online courses (MOOCs) (Reich and Ruipérez-Valiente, 2019). However, various studies show that retention rates overall are typically very low (usually around 10%) when compared to the conventional classes (Greene et al., 2015). Moreover, there is an important effort to adapt the pedagogy of conventional presential programs to distance learning, which usually requires professorial training and investment on IT solutions to cope with the teaching framework.

Therefore, the initial IT project to introduce distance learning focused on the engineering track program for those courses related to well established contents, and it was addressed mainly to foreigner students. The project was completely modified due to the COVID-19 crisis. Due to the confinement decision, the IT department was confronted to adapt their strategies to ensure the main mission of the institution that was to ensure the continuation of all high-education programs through videoconference.

Different from the previous study case, the scenario 1 (postpone project) was not an option. However, not only resilience was required, to mitigate social risks, but also a deep reorganisation to ensure the whole teaching activity through distance learning. Professorial training had to be maintained, which were already implemented as project adjustments to control the production launch milestones.

5.2 Actions to perform in order to secure the project

Based on the framework presented on Section 2, and considering the triangle of dimensions and the elements to increase operational efficiency of interventions, we describe in the following the actions that were carried to ensure project resilience regarding the specific situation of the high-education teaching.

5.2.1 Prepare and anticipate risks

The implementation of a distance teaching solution became the main project of the IT service since the announcement of the confinement. Nevertheless, even though most people thought that the main challenge was the definition of the online platform/software, the real threat was the network infrastructure to allow classes to happen in parallel and with a great number of users. The reactivity to establish a reliable, performance and efficient solution was an essential functional requirement to ensure the core missions of the institution.

The project that was not a priority for the IT service up to the crises was rescheduled and established as highest priority and restructured in a very short time to enable the institution to not disturb the agenda of different teaching tracks.

5.2.2 Risks strengthen organisation

As the previous study case, the project was depicted with strong governance with many levels of decisions, which is not the usual functioning of a high-education institution

which usually lies on horizontal management. The strong governance was a result of the requirement of an active coordination within the whole structure, including teaching departments and coordination with all the main directors of the institution.

The IT workforce was used to a horizontal functioning where teams were quite independent. Due to crises circumstances, they were obliged to work in coordination and a lot of attention was allocated to ensure tolerance and good will between team players. As a matter of fact, team meetings at different levels were organised in a week basis to ensure coherence and coordination between staff members and teams. The crises also brought a common enemy that help to foster team spirit and promote adaptability.

Since the establishment of the project milestones, IT workers were assisted to organise their working schedule based on objectives of the project, which allowed an extensive possibility in terms of personal time schedules. Teleworking equipment was already available to provide the organisation the ability to adjust the team. If it was not the case, the project would probably suffer from additional delays.

5.2.3 *Ensure efficient interventions*

As previously established, the success of the project largely relies on the capability to intervene on unpredictable situations as well as the clear definition of functional objectives. Risk's identification and responsibility are key elements to ensure intervention's efficiency.

An academic institution, and particularly the teaching activity, relies on two classes of individuals, i.e., professors and students. The feedback assistance deployed by the IT department to address to professors and students was extremely important and it helped the IT department to intervene as soon as the problems appeared. The follow-up of these interventions was a great key asset to identify risks. Based on the centralised organisation of these interventions, where all users' solicitations, from professors and students, were concentrated in a single database, the IT team was able to measure the recurrence's probability of identified problems, allowing them to prioritise their actions based on users' feedback. Thus, continuous improvement of the system is ensured through the progressive implementation of new features which facilitate the organisation's functioning.

During a crisis, human resources usually present a challenge due to unexpected urgencies that appeared, which often disturbs the established organisation of the teams. The deployment of tools to assist teams to prioritise tasks helps to mitigate stress on team members and ensures stability on the service missions.

6 **Conclusions and perspectives**

In the present article, the authors proposed a simple and effective method to improve the resilience of IT projects for

public services. As underlined in the literature review, resilience is a complex topic with various definitions and approaches. The most widespread definition of resilience corresponds to the ability of a system to recover after an unpredictable sinister. The scientific literature also outlines that building resilient IT systems requires to develop a system and multi-factorial approach. Whereas researchers proposed a multitude of theoretical approaches there are relatively few methods that are detailed up to the implementation.

In the current paper, the authors lean on the literature to define an operational methodology to enhance the resilience of IT projects in the context of public services. Thus, they underline four related dimensions involved in project management and explain how they may be improved and one dedicated action for each of them. The functional perspective is rather original compared to the literature on resilience as it tackles the constraints defined by the project sponsors and partners. The authors propose to strengthen the organisation, ensure efficient operational interventions, identify functional action-levers, and manage the project in the crisis context.

The authors focused on the operational level which is essential to cope with a crisis. They propose multiples levers to mitigate risks and improve the ability to manage a deep crisis:

- 1 strengthen the organisation
- 2 ensure clear and efficient operational interventions
- 3 identify functional action-levers
- 4 manage the project in the crisis context.

Finally, they illustrate their proposal by two case studies in the domain of public services. The first one concerns the modernisation of Personal Income for the French Tax Administration. The second one concerns the resilience of teaching education at a French engineering school (CentraleSupélec). Both case studies demonstrate the interest of anticipating pandemics, adjusting during the crisis and improving continuously.

There are many lessons learnt by the analysis of the two case studies. Appropriate governance plays an important role in the response and recovery phase of a crisis. When the governance is overwhelming, the response is too slow; on the contrary excessively restricted governance does not enable to obtain action levers to solve complex problems. Thus, ensuring resilience requires to define a simple and transversal crisis organisation with appropriate actors in terms of skills and authority.

Another important dimension of resilience relies on the experience and training of workers as well as their possession of performing machines, tools, softwares and configurations. As a matter of fact, the continuity of service may be ensured as workers may be involved rapidly and dispose of every instrument to cope with any type of unexpected event. Future work should consist in developing the other dimensions which can improve project resilience and completing the work with new case studies.

Current post-confinement situation reveals the importance to reconsider work processes by developing teleworking but also hybrid collaboration. This corresponds to the capability of combining sequentially and even simultaneously on-site working and home working. New working practices should be proposed for stand-up meetings, daily reviews, or software demos. Similarly, the academic professors are defining new teaching methods to mix presential and distancial learning in full class or small groups. Another issue to define resilience strategy relies on the importance to rethink past practices such as large open spaces, single corporate office, etc. Finally, the COVID-19 crisis highlighted the decisive adaptability of workers that adjusted quasi-immediately to a new working environment. This praises to focus, develop and promote soft skills such as autonomy, adaptability, or initiative throughout the organisations.

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