Vision on the role of technology demonstrations in ATM innovation

"X-Environment"

Final version 20-04-2018

Ferdinand Dijkstra (FerWay)

Fredrik Eriksson (MovingDot)

Maarten Zorgdrager (NLR)

Definitions

Definition	Description
Business critical processes	The operational processes used by OPS existing of both on-line/live OPS-data processes (e.g. for LVNL OPS Management) and off-line OPS-data (e.g. for post-OPS analysis and reporting) These processes are untouched by X-Environment.
Functional concept (elements)	The functional concept (elements) resulting from the initial test which are subsequently via an iterative process demonstrated in the operational demonstration.
Initial test	Initial visualisation and assessment of high-potential ideas in X-Environment.
One-way gateway	Extraction of data from the operational on-line systems with a filter that can be manually adjusted (e.g. filter to only specific data elements).
Operational concept (elements)	The operational concept (elements) resulting from the operational demonstration which are subsequently to be implemented.
Operational demonstration	Demonstration of new functional concept (elements). This can be demonstrated in the operational environment. By demonstrating in an X-Environment close to the operation the operational users are challenged and inspired and support and acceptance is encouraged in a transparent way.
X-Data off-line	Off-line X-data that is extracted from the X-data on-line environment and stored. The off-line data feeds analysis of different kind in order to innovate new concept (element). Off-line data also forms the basis for the design of scenarios.
X-Data on-line	On-line X-data is extracted from the operational on-line systems via the one-way-gateways. This data supports small scale projects. The actual on-line situation is used as baseline and small innovation elements are added to this and demonstrated in the operation.

1. Introduction

1.1. Background

The aviation world is in constant change and the pace of change is increasing. The arrival of new technologies and new demands from users and customers are driving the change. It is important for the Dutch aviation sector to not only be part of the changes but to be at the forefront of the developments most relevant to the Dutch situation. All stakeholders in the Dutch aviation sector recognise this and they all run research and development programs to this end. The Knowledge and Development Centre (KDC) is a unique way in which the Dutch aviation sector cooperates to deliver pioneering development for Mainport Schiphol.

One common hurdle in development of ideas that all stakeholders face is the step from research study to implementation. Many promising ideas do not make it to implementation because they either do not fully fill an operational need or when they do it is difficult to clearly demonstrate the

effectiveness of the solution. The result in both cases is lack of support from operational personnel and as a result projects are terminated before implementation. Difficulty in accessing operational relevant data for testing and demonstration a major contributing factor to this problem. The result is that developments are often costly, cumbersome and inefficient. KDC in its work to promote and support development in the Dutch aviation sector would like to address this issue by the development of an experimental environment in which operational data is readily available and where research studies can be brought to a mature stage and made ready for possible implementation. This must include both technical readiness as well as user acceptance. These aims are in line with the lean innovation method which KDC embraces. The goal of lean innovation is to learn fast and fail cheap.

1.2. Scope

The overarching development process for aviation sector projects can be divided into three main steps, idea generation, validation and demonstration of ideas, and implementation of developed ideas. This vision document focuses on the middle step, validation and demonstration. The experimental environment, called X-environment, starts after idea generation and supports development of the idea. Taking it through several steps of validation and demonstration of usefulness and making it ready for implementation. Hereby it is important to mention that the more mature an idea/project becomes the smaller the uncertainty and resistance under Operational Experts and the larger the usability and acceptance.

Validation of project ideas is crucial to a high-quality development and it is performed iteratively in the X-Environment. Low-cost / small scale validations will be done within the X-Environment, however it is expressly not the aim of X-Environment to become a large-scale validation facility, such as a Fast Time or Real Time Simulation facility. For large-scale projects there will be another validation step between X-Environment and implementation by making use of e.g. a Fast Time or Real Time Simulator. Figure 1 shows the place of the X-Environment in the development process.

Figure 1, Overview of high level development steps showing the place of X-Environment in relation to other steps.

Summarizing, X-Environment is a facilitator for carrying out projects by enabling access to data from operational systems. It is not a validation tool in itself, like a simulator, but rather an environment that provides the right data and processes to effectively work with the data.

1.3.Goals

The goal of this document is to set out the vision for how an X-Environment for the Dutch aviation sector should be set up and used. The document aims at supporting decision making and facilitate efficient and coordinated development. It will describe the different stakeholders and their needs, roles, and responsibilities in the creation and maintenance of the X-Environment.

1.4. Involved stakeholders

The X-Environment will be setup and maintained by the KDC partners, KLM, AAS, and LVNL. They are responsible for supplying the relevant operational information to fill the X-Environment. They are also charged with managing the X-Environment such that it is operational and that it stays useful for project development now and in the future. Through the KDC activity they are also responsible for providing development projects for the X-Environment.

DGB is responsible for approving KDC projects including projects that will be using the X-Environment for their development.

The KDC suppliers, MovingDot, NLR, FerWay, To70, KNMI and TU-Delft will work with the X-Environment to efficiently develop KDC research ideas into implementation ready projects that will contribute to strengthen the Dutch Aviation sector.

2. Vision

2.1. Overview

The goal of X-environment is to bridge the gap to implementation by validating assumptions close to or in the operational context. This enables studies to be better suited to the operational environment enhancing support from the operational personnel. By demonstrating in an X-Environment close to the operation, the operational users are challenged and inspired. Next to this, support and acceptance is encouraged in a transparent way. This way the chances of successful implementation of new innovative concepts are increased. This can both be driven by specific questions from the operation (pull) and by demand from a project/brainstorm (push). Another input for innovations that is promoted by the X-environment is the ability to perform evaluation of operational functions.

In the introduction of X-environment, technical aspects as well as behavioural aspects and organizational aspects will play an important role. After all, the effect of a change is defined by the quality of the solution times the acceptance by the operational stakeholders. An X-environment that is supported within the organizations is crucial. It will allow testing of innovations before they are put into the operation. No innovation without intrinsic motivation. This also ensures that solutions, which have been shown to be inadequate, are kept away from the operation.

2.2. Definition of the vision elements

Figure 2 provides a schematic overview of the X-Environment as a client of the operational system. In this figure also the business critical process of OPS is visualised on the right-hand side. The example in the figure is based on ATM data from LVNL but the principle applies to the systems of all KDC partners.

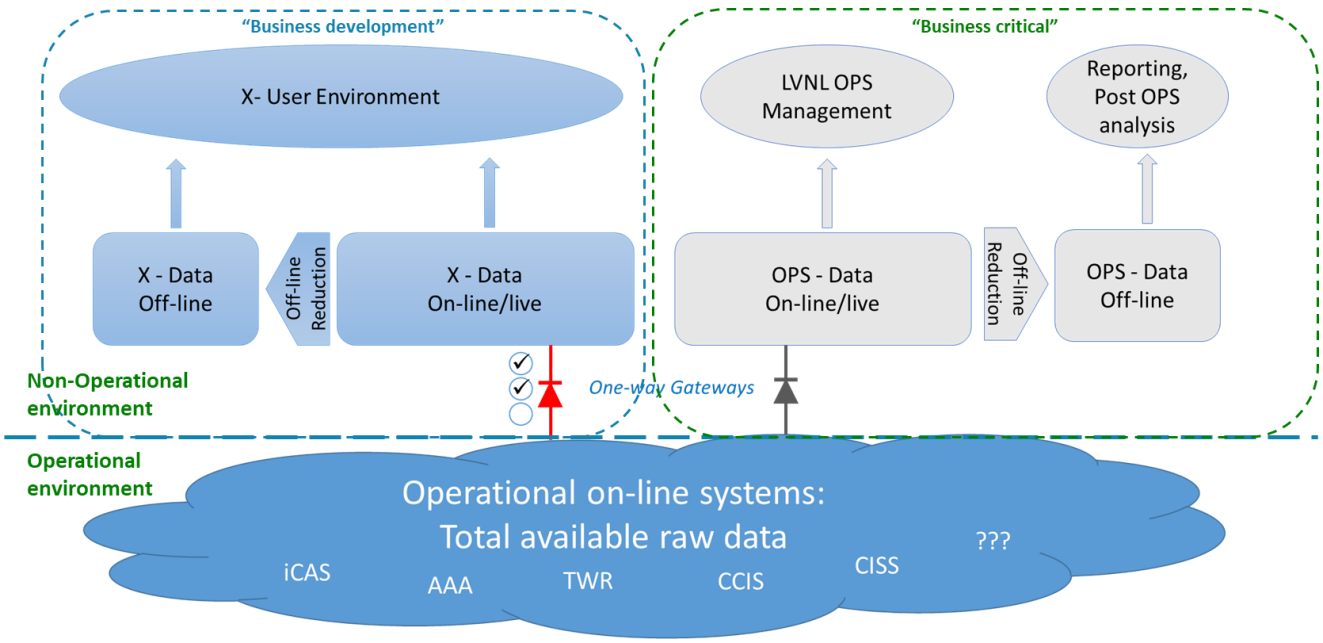

Figure 2: Schematic overview of X-Environment as a client of the operational system.

The technical ATM System comprises a collection of individual systems such as AAA, CCIS, etc. Operational personnel use these operational systems to perform their tasks. The total amount of data available in this collection of operational on-line systems is enormous. A part of this raw data is extracted from the operational systems into the on-line OPS data. Information in this collection is also recorded for legal, business and analysis purposes. Both the on-line data in this cloud as well as the recorded information are voluminous.

X-Environment makes use of a one-way gateway to also extract information from the operational on-line systems. In this one-way gateway a filter is placed to be able to manually select the required data. Subsequently on-line and recorded data are exported in a safe way to the non-operational domain where it can be used for the purposes mentioned.

Due to the sheer amount of available (recorded) data, a selection (reduction) of the data is made at different levels for the non-operational domain. The levels determine the amount of data reduction and the time period the data are retained:

- Information needed in real-time: a selection of the real-time data is made available to the client non-operational systems, like management information systems or prototype systems for a live operation (real-time, no (long) history).
- Information for systems/legal analysis: a copy of all recorded data is made available to system engineering and legal purposes (1-4 months)
- Information for business reporting (10+ years)
- Information for operational analysis (10+ years)

There is a major distinction in this disparate group of data stakeholders: one group is business critical (operational management, judicial requirements and business reporting). These stakeholders require high-availability and stability of the information provided. The other group of stakeholders require more flexibility as to which data can be selected and analysed or applied for business

development purposes, e.g. on-line/off-line prototyping, testing of shadow systems, statistical analysis, etc. Therefore, two distinct groups are identified and mapped to the technical domain to ensure compliance with these uses and constraints.

2.3. Systems Vision

2.3.1. System elements

The X-environment system is a client of the operational data. It needs to obtain this information in an independent manner, without interfering with the information provision to the business processes. This is achieved by performing extraction via two separate pathways: one feeding business critical use of the data and the second path feeds business development activities, the X-environment. The extraction process for the X-environment gets raw data from the available systems similar to the method used for the business critical use. This translates into extracting data in a secure way without influencing the behaviour of the operational system. In effect, two copies of the operational data are extracted in a secure way.

Applying the separation already at the extraction level ensures all goals can be achieved of the stakeholders with their diverse needs and conditions for access and use.

The process in the business critical section should be treated as part of the regular business change model with all applicable restrictions regarding modifications. Hence this section is kept separate from the X-environment on all levels: technically, functionally and operationally.

The process of business development in X-environment can and should be subject to fewer restrictions since business critical applications are completely isolated from it. This facilitates the intended use cases of the X-environment. Modifications in selection, long-term storage and processing of data as well as in making on-line data available to stakeholders can be implemented fairly quickly due to the less restricted process.

A separate project database is set-up comprising administrative information regarding X-Environment project. This information will document the projects that have been considered, tried and executed. Considerations for acceptance, rejection as well as results can form part of the data stored. Such documentation will provide a knowledge database for considering new ideas as well as while executing ideas in the X-environment.

2.3.2. System constraints

Location & access

The location(s) of the X-environment equipment is considered an architecture decision. However, the architecture choices should allow for the implementation of the high-level view on the X-environment and facilitate stakeholders needs like application in the operational environment and easy access.

Availability

- Continuity: in case of changes in the operational system, X-Environment will follow. There will be no missing data in the X-environment as a result of such changes as far as practicable.
- Availability: data sources are available 24h.
- Security of X-Environment data: most data is confidential/sensitive, all data needs to be handled, manipulated and stored in a secure way and access controlled way. System is independent. Storage, use of portal, maintenance personnel, downloading data to local computer, classification of data security level, X-Environment user clearances.

2.3.3. Process description

- The X-environment starts with input from the ideation process.
- Ideas have to pass an initial gate to be included in the X-Environment comprising of a checklist to see if an idea is:
    - In line with vision KDC partners?
    - Adding value to the organisation(s)?
    - Checked against project database?
    - Based on which assumption(s)?
- Ideas that are accepted into the X-environment become X-projects
- All worked out ideas are registered in the project database. This to allow follow up and allow for checking duplicity of ideas.
- Project defines its requirements and goals.
- Projects can go through two development phases: desktop and operational demonstration.
- Functional concept elements are developed in desktop settings. The project idea is developed and iteratively tested against the project requirements and goals, and how well they solve the issue. Several projects are expected to be vetted in this process as they are shown to be not viable.
- Functional concept elements that are viable may, when appropriate, continue to the operational demonstration phase where the project idea is further developed. The Operational concept elements are tested in operational demonstrations where operational personnel can assess the project ideas for usefulness and for how much they contribute to solving issues.
- Projects that are successfully developed into viable operational concepts are delivered from the X-environment to the KDC partners who may then decide to implement the concepts within their respective organisation.
- All steps and decisions are captured in the project database for future reference.

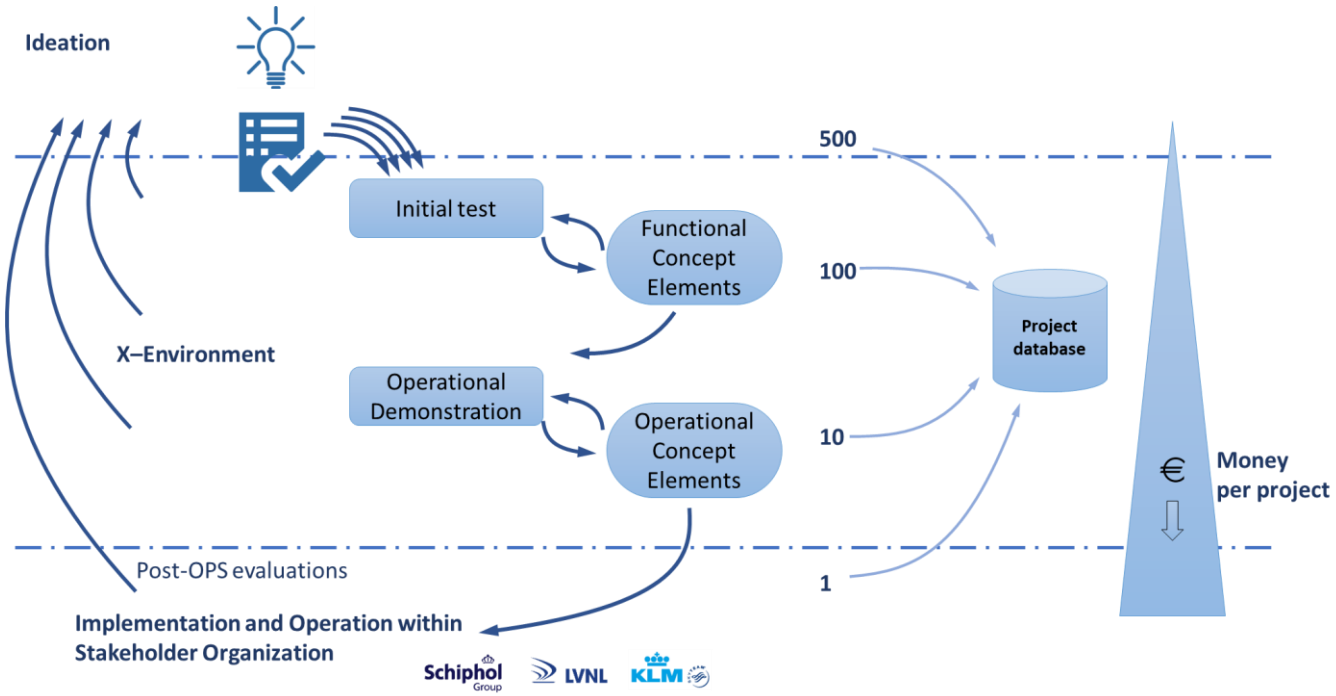

Figure 3 X-Environment process description

2.3.4. Lean innovation

X-Environment follows the principle of "lean innovation" which comprises a value driven approach, rather than a technical driven approach.

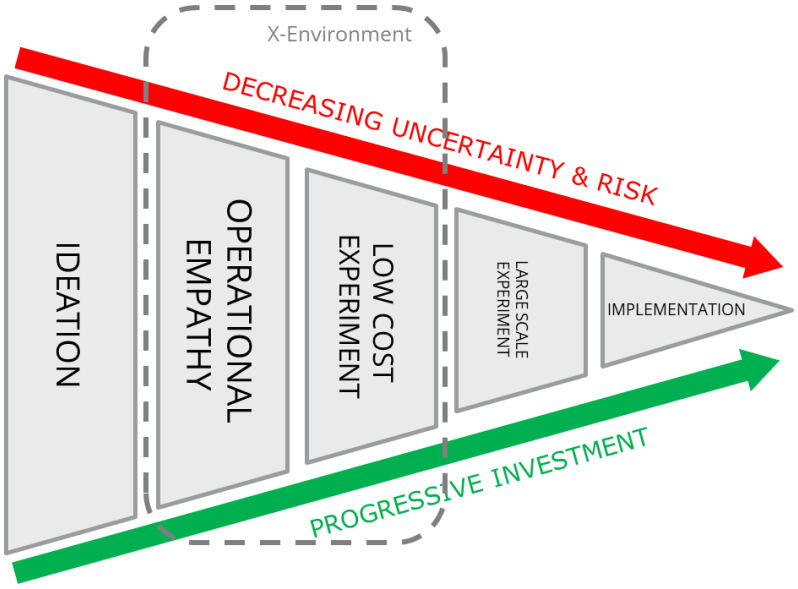

Figure 4: Lean innovation cycle in X-Environment

In general, experimenting enhances the implementation; however experimenting is often complicated, expensive and slow. That is why X-Environment can create a permanent environment

to test assumptions and validate innovation steps. The further an idea gets in the X-Environment cycle, the smaller the uncertainty and risk becomes and the larger the progressive investment becomes. This minimizes the risk of the different types of waste as illustrated in Figure 5.

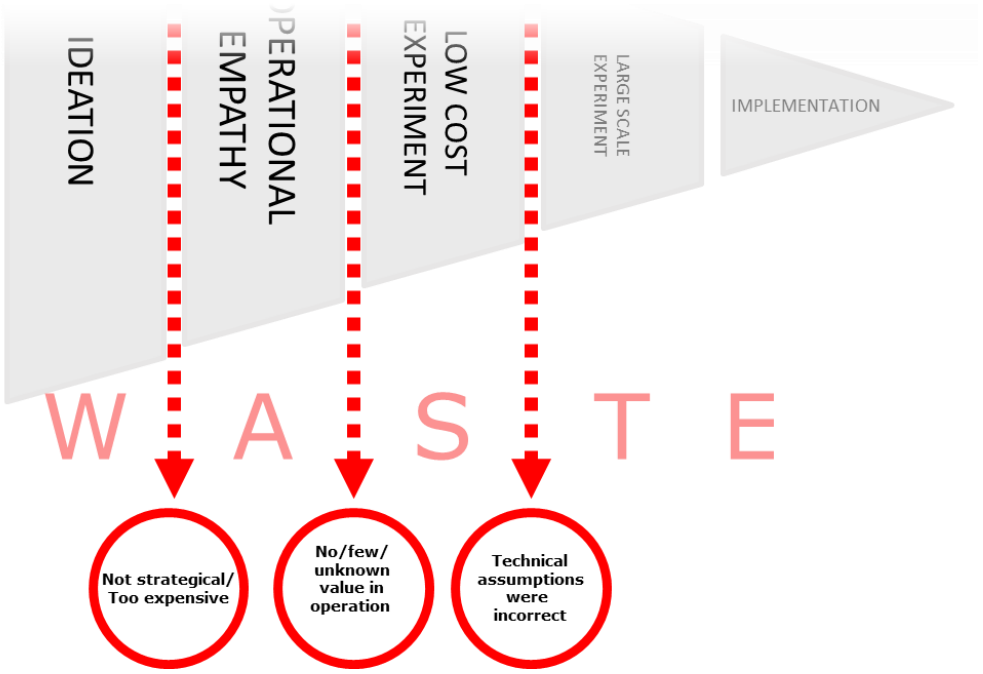

Figure 5: types of waste in innovation cycle

The benefit of the lean innovation method will be visualised based on the following example. Assume that in one of the KDC organisations 10 new ideas are proposed to be worked out as a project, each with a projected development budget as visualised in Figure 6. Traditionally a budget equal to the sum of all individual projects will be budgeted.

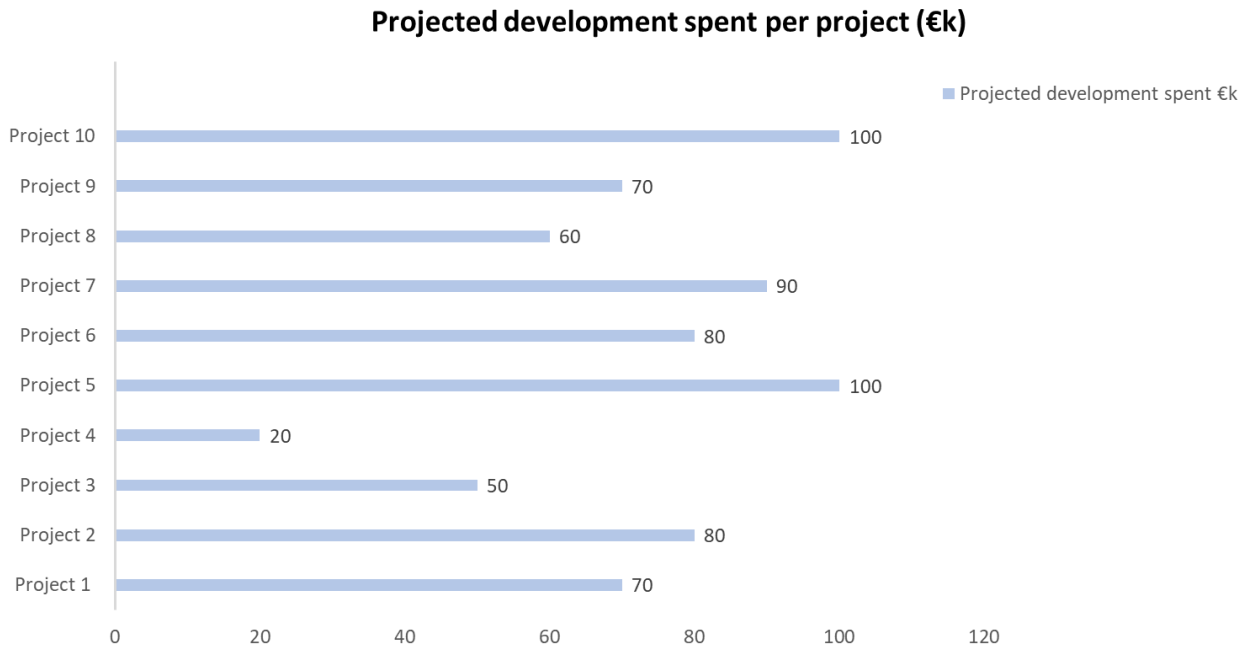

Figure 6: Example project development spent per project

Now following the lean innovation methodology "learn fast, fail cheap", it means that ideas are evaluated at an early stage based on its potential and are killed if the added value is not satisfactory. This leads to responsible further investment and for the example a reduction of actual development cost of €15.3M versus the projected €72M. This saving can subsequently be used to evaluate more new ideas in X-Environment or to finance the implementation of the persevered project(s).

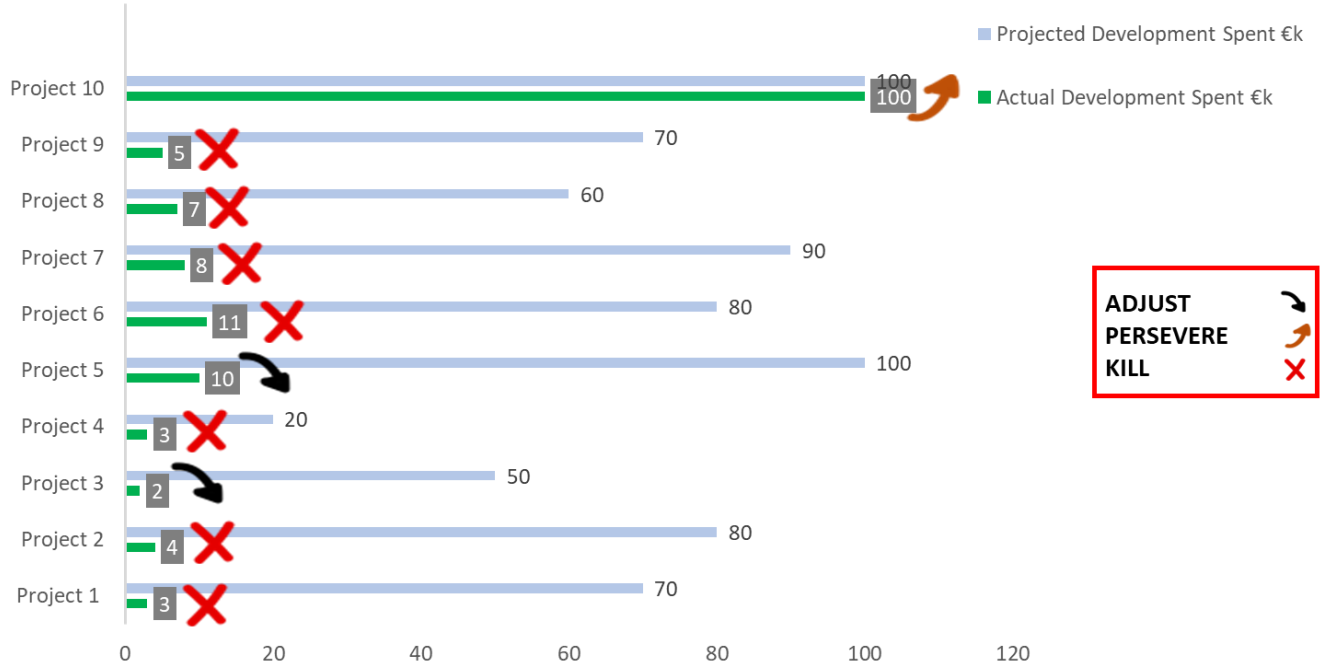

Figure 7: Actual vs. projected development spent per project

2.4. Roles & Responsibilities

KDC management will be responsible for project related questions such as project data availability, project financing and project resources.

Next to this, a maintenance group will be formed by either the KDC partners or possibly an external party in the future. The role of the maintenance group is:

- Providing maintenance: ensuring continuity, access, availability and security of X-Environment data;
- Configuration of X-Environment data: selection, filtering and storage of data.

KDC will be responsible for the initial gate review of project ideas and to update the project database.

The users of X-Environment comprise KDC suppliers, individual KDC partners & ILenT. The roles of the users comprise:

- Carrying out research and development projects/studies in X-environment
- Complying with rules for access and use of X-environment data;
- ILenT for early involvement in concept development (for creating understanding and allowing for efficient certification and implementation).

Figure 8 provides a schematic overview of the different X-Environment stakeholders.

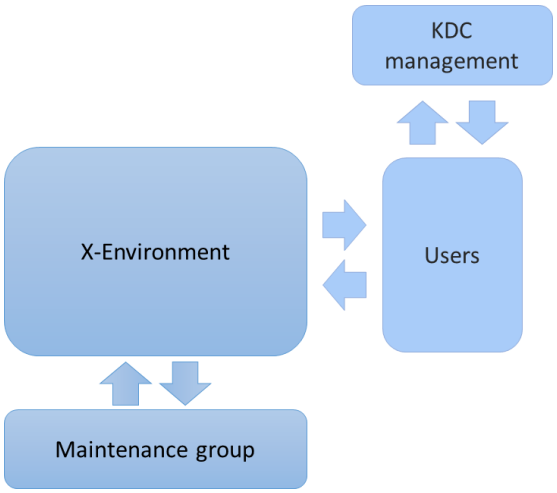

Figure 8: X-Environment hierarchy

3. Roadmap for implementing X-Environment

Data and processes for research & development within the Dutch aviation sector are in place within the individual KDC-members organisations. Still development of an X-Environment is complex since it requires cooperation and sharing data between stakeholders. To ensure continued commitment by all KDC-members it is important to set-up an agreed development path. One approach to this is outlined in the road-map below.

X-Environment roadmap

1. Describe the basic process for the use of the X-Environment in detail. This will ensure that all KDC-members have a shared view of what the X-Environment is, what it can contribute, and what their role in its setup and maintenance is. It should cover the following aspects:
    a. All steps for a development project from idea to implementation ready.
    b. All steps of project administration and registration.
    c. X-Environment maintenance process and responsibilities.
    d. Communication activities to inform stakeholders of activities and accomplishments in the X-environment to achieve strong engangement
2. Determine process and technical requirements for the X-Environment. This should include:
    a. Identify which data to be incorporated and de available data sources.
    b. Determine interfaces for users and maintenance groups.
    c. Determine hosting and maintenance strategies.
    d. Decide on data security and access rules.
    e. Identify project database data content and setup.
    f. Structure of project database.
    g. Initial gate checks and requirements.
3. Decision point – Requirement acceptance by all KDC-members to ensure continued support.
4. System design and implementation of X-Environment on basis of the agreed requirements.
5. Document the design and implementation steps.
6. Document the X-Environment process on basis of the agreed requirements.
7. Decision point – Commissioning agreement by all KDC-members to ensure continued support.
8. Commission X-Environment making it fully functional and ready for use.
9. Execute X-Environment development projects.
10. Maintain X-Environment

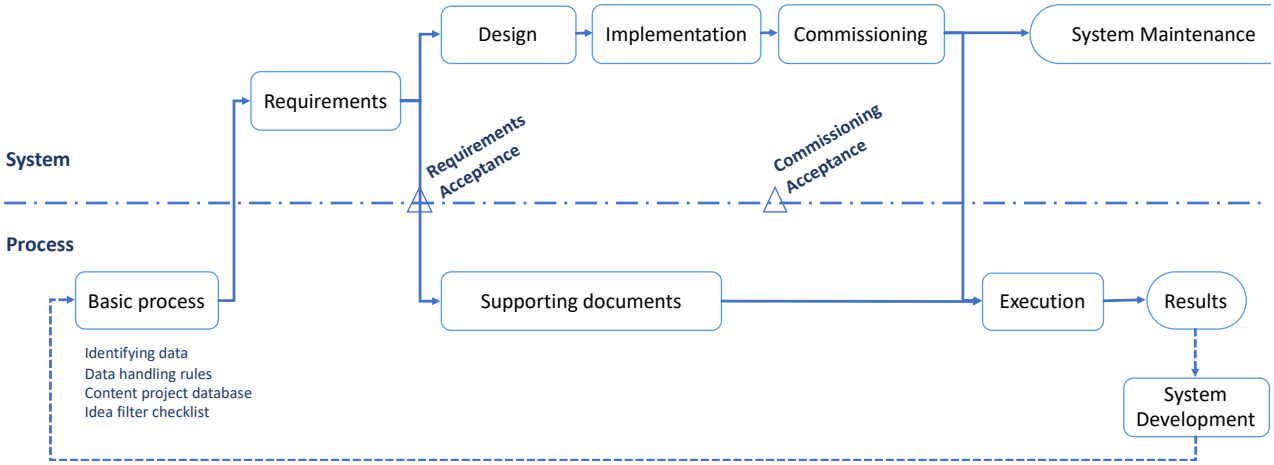

Figure 9: X-Environment roadmap

Appendix A: Pilot Project EHAM Outbound Predictability for MUAC

Introduction:

The pilot project for the X-environment is intended to show capabilities that are fundamental to the Vision on the X-environment. At the same time however, as this will be part of the initial step of its development, not all capabilities can be considered to be available. Moreover, the X-environment's Vision states that it is a continuously evolving environment, capabilities will therefore always change and be enriched.

In the definition of this pilot project however, key aspects of the vision are intended to be touched by the assignment. This especially applies to the aspect of on-line availability and fostering rapid prototyping with operational data. These elements are considered crucial components in bridging the gap between innovative research and eventual implementation.

Goals & Requirements:

Overall goal: Show initial X-environment capability by demonstrating improved outbound predictability for MUAC in an on-line environment. The Capacity Management department of MUAC has indicated that the predictability of the Schiphol outbound traffic is lacking sufficient accuracy. This may lead to sector overloads or different types of traffic restrictions that could have been prevented. Several potential sources have been identified, it is however not clear as to which factors are most contributing to this issue, or the predictability required by MUAC. The idea to test in the X-environment is to:

- Measure the current predictability
- Establish the contributing factors
- Devise and test solutions

Requirements for actual project:

1. Show predictability information quality of traffic departing EHAM towards MUAC. This information shall, at any time, reflect, on-line, the past situation till current time.
2. Show actual predicted traffic loads produced by a prototype system leveraging best available on-line information. This may include the use of an advanced/prototype Trajectory Predictor.
3. The predicted traffic load information shall be shown in comparison to a predicted traffic load based on existing data being sent to MUAC.
4. The traffic load determination shall be the same for both input sources.
5. Show possibility to create a prototype system without dependency on operational system modifications.
6. The project will not affect any business critical processes

Scope & Operational Context:

- The information shall be shown in a prototype system that can be viewed both at LVNL and MUAC premises. For instance by showing flight details and predictions on tablets available at operational working/supervisor positions at both sites.
- The system will not be directly connected to operational LVNL systems.
- Information shall apply only to the day at which the prototype is used, i.e. passed information will not be older than the last midnight.
- Information used to derive improved predictions shall originate from at least 2 distinct LVNL ATM sub-systems.
- Predictability information shall be limited to traffic counts for specific designated coordination points and time intervals.

Limitations to the level of sophistication of the data and models used may apply as the initial build of the X-Environment may not deliver the full scope of the targeted X-environment

Summary of elements from X-Environment Vision applied:

a) Ability to extract from different system sources in the LVNL operational ATM System on-line data in a safe and secure way during both the initial test and operational demonstration.
b) Retain information from a) for aggregate and historical analysis.
c) Development of prototype systems using a short development cycle:
    a. from initial test, functional concept elements (predictability solutions) are derived
    b. the predictability solutions are implemented in a prototype to be subsequently evaluated through Operational Demonstration
    c. after possibly several iterations of b. definitive concept element solutions are recommended for implementation.
d) Once the recommendations from c) are implemented, the X-environment can be used to analyse the performance of the innovation.