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Rapport

Project Report

Improving Azure Pipelines DX: A Smarter DevOps Experience

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13 January 2025

Draft

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Project Report

Improving Azure Pipelines DX: A Smarter DevOps Experience

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1. Context

1.1 How to read

This report provides the most complete walkthrough of the entire project from start to finish. However there is an accompanying website (https://grad.serggio.dev). Most links point to the portfolio website for additional content; an additional 'local' link is sometimes provided, this link is relative, thus will only work in the submission folder.

1.2 Company

Info Support is a leading consultancy agency founded in 1986. Info Support provides consultancy services and custom-made software solutions to large, well-known companies such as OVPay, Albert Heijn, Jumbo, and Enexis. The company operates internationally, with over 800 employees across five companies. Info Support works across five key sectors: Agriculture & Food, Finance, Healthcare & Insurance, Industry, and Mobility & Public. In addition to its consultancy and software development services, Info Support also focuses on training both internal and external personnel. The company offers certification training in seven fields and provides specialized minors for students, helping them gain expertise during their education.

1.3 Problem statement

Developers often struggle with identifying and resolving errors in Azure DevOps CI/CD pipelines due to the lack of robust local validation tools for the YAML files defining these pipelines. Currently, the only method for validation is committing and testing changes directly in the Azure DevOps environment, which is time-consuming and disrupts workflow efficiency.

This absence of local validation creates repetitive and slow iterations, requiring developers to submit changes to version control, await feedback from CI runs, and address errors. The situation becomes even more challenging when pipelines incorporate multiple shared templates, each introducing unique parameters and considerations.

Common errors such as typos, missing or incorrect parameters, and misuse of variables exacerbate the problem. Each template can introduce its own variables, including nested ones, making the environment increasingly complex and unmanageable. Developers often face long wait times for CI jobs to run, slowing down even minor corrections, such as fixing a typo. This process: saving the file, committing changes with a message, pushing to the repository, waiting for CI to pick up the changes, and running the pipeline to locate the error; can take several minutes for each iteration. Consequently, trivial issues can result in significant delays, productivity losses and developer frustration.

Improving this workflow with real-time, in-editor feedback would drastically reduce these inefficiencies, enhance developer productivity, and reduce frustration.

1.4 Research

Throughout the assignment research will be conducted using the DOT framework. We primarily wish to create a tool that will eliminate or reduce pain points.

To manage the scope of the project we first need to find out what the main pain points even are, in the development process of Azure pipelines, and how they can be alleviated by using static analysis. In other words, how can we best alleviate frustration without running the pipeline.

The main question for the project will be:

How can static analysis be applied locally to Azure DevOps pipeline files to maximize mistake prevention before pipeline execution?

From this question stem the following sub-questions:

1. How do Azure DevOps pipeline files function, what are their key components and what are the processes that result in their execution? (Literature study)
   a. Dive through the Azure DevOps official documentation to understand the syntax and features available.
   b. Explore how Azure DevOps parses and executes pipeline YAML files.

   Outcome: Flowcharts or diagrams to visually represent the execution flow of a pipeline.

This question was ruled out during the course of the project.

After further discussion, it was determined that summarizing Microsoft's Azure DevOps documentation did not provide new insights or added value to the company. Instead, this question served as a guide for personal learning, contributing indirectly to the tool's development. The knowledge gained was incorporated into the tool and its accompanying documentation but was not pursued as a standalone deliverable.

2. What are the common mistakes and errors occurring in Azure DevOps pipelines, and how can they be identified? (Problem analysis, Root cause analysis)
   a. Gather internal documentation, incident reports, and feedback from developers at Info Support or external to identify common errors.
   b. Analyse patterns of mistakes.

   Outcome: A list of errors, ranked by the impact they would have if resolved. The impact would be informed by the frequency of the error among frequent developers. This list will inform the next stages of development.

This research went beyond providing a list of errors and assembled a comprehensive set of recommendations along with their impact.

3. Which static analysis techniques and tools are best suited for detecting mistakes in Azure DevOps pipelines? (Available product analysis; Choosing fitting technology)
   a. Evaluate existing static analysis tools, techniques, and methods (e.g., linters, syntax checkers)
   b. Assess the feasibility of incorporating or adapting these techniques into the tool being developed.

   Outcome: A clear decision on which analysis techniques will be used and what custom rules need to be implemented.

As opposed to writing a single research document, separate ADR's were written as new techniques or technologies were introduced in the project.

4. How can a static analysis tool be developed to integrate into development workflows while ensuring high performance and compliance with internal guidelines? (Prototyping, Non-functional test, Unit test, Product Review)
    a. Develop the prototype of the static analysis tool, incorporating selected techniques and custom validation rules.
    b. Ensure the tool integrates well into existing toolchains and adheres to company guidelines.
    c. Keep performance in mind, as to aim for below 1 second validation.

Outcome: A working prototype of the static analysis tool tailored to Info Support's needs.

1.5 Approach (local)

The project follows an agile methodology using Kanban with sprints. Kanban is well-suited for individual work due to its flexibility and simplicity. It allows for continuous task management and adaptation to changing priorities without the need for formal iterations or roles, which would mostly be taken by the student. Throughout the project, the approach shifted to emphasize **vertical slices** within sprints, delivering incremental functionality.

Initially, the project followed a phased plan that separated research, development, and documentation. However, this structure led to challenges in managing concurrent progress, creating a chicken-and-egg problem: in some cases, it was unclear what to develop without first knowing which techniques to use, while in other cases, it was difficult to determine which techniques to research without understanding the requirements of the implementation. This circular dependency caused delays. By Week 12, the approach was revised to integrate research and development into sprints, allowing for iterative progress and addressing techniques as needed for each feature.

By Week 15, the plan was further refined to focus on **template parameters** and **variables**, reducing scope to accommodate the remaining timeframe while ensuring the delivery of core functionalities. A contingency sprint (Sprint 5) was added to allow further coding efforts after the documentation deadline, targeting features that were deprioritized earlier.

The iterative evolution of the approach enabled the project to remain aligned with its goals despite setbacks, delivering a functional tool and comprehensive documentation while maintaining flexibility for future enhancements.

A more extensive description of the approach can be found in the portfolio site.

2. Conclusion

Main Question:

How can static analysis be applied locally to Azure DevOps pipeline files to maximize mistake prevention before pipeline execution?

Static analysis can be applied locally to Azure DevOps pipeline files through a dedicated tool that parses pipeline YAML files and evaluates their syntax, structure, and embedded expressions. By leveraging real-time diagnostics via a Language Server Protocol (LSP) implementation, the tool effectively provides developers immediate feedback on potential errors, enhancing mistake prevention without requiring pipeline execution.

2.1 How do Azure DevOps pipeline files function, what are their key components and what are the processes that result in their execution?

This question was removed as a standalone deliverable since its answer would primarily involve summarizing Microsoft's documentation, which would not add significant value to the company. However, it identified a knowledge gap that was addressed through company training and further learning during the project's development.

2.2 What are the common mistakes and errors occurring in Azure DevOps pipelines, and how can they be identified?

The most problematic features, where errors occur, were compile-time expressions, stage-level variables, predefined variables, and template parameters. These errors were identified through a survey and interviews with Info Support developers, using a weighted scoring model to prioritize issues by their impact and frequency.

This is further explained here.

2.3 Which static analysis techniques and tools are best suited for detecting mistakes in Azure DevOps pipelines

A parser was determined to be the most suitable tool for handling compile-time expressions, more specifically Tree-sitter was chosen as the most suitable parser. This due to its ability to recover from errors; it offers an easier implementation process using JavaScript for grammar; aligns well with the need for real-time feedback; and supports integration with multiple programming languages.

Further, custom diagnostic rules were implemented to address pipeline-specific errors. Decision records documented the rationale behind these choices. In the 'Parsing strategy', we determine how to tackle parsing, and in 'Parsing Solution', we determine the best suited technology.

2.4 How can a static analysis tool be developed to integrate into development workflows while ensuring high performance and compliance with internal guidelines?

The development of a static analysis tool for Azure Pipelines has been guided by several core principles aimed at ensuring seamless integration into existing development workflows, maintaining high performance, and adhering to internal guidelines.

From a technical perspective this is detailed in the Software Architecture, and a practical rundown is available in the Approach. Additionally the rationale for the decisions have been recorded using ADR's, which are available here.

2.4.1 Establishing guidelines

To ensure a project like this meets all its goals, it is crucial to establish a detailed set of requirements at the start, particularly **non-functional requirements**. These requirements define the standards for performance, usability, scalability, and maintainability, serving as a foundation for design and development decisions.

2.4.2 Integration into Development Workflows

To integrate smoothly into the development environment, the tool leverages the **Language Server Protocol (LSP)**. LSP allows the tool to communicate with multiple Integrated Development Environments (IDEs) such as Visual Studio Code and Neovim, without the need for custom solutions for each environment. This ensures **IDE independence** and reduces setup time for developers, meeting the **Seamless Integration** requirement of the project.

2.4.3 Ensuring High Performance

Performance is a critical aspect of the tool, particularly in the context of real-time feedback. To achieve this, the tool utilizes Tree-Sitter, a fast and efficient parser that ensures minimal delay in feedback even for large and complex files.

Additionally, the tool's modular architecture separates the **Language Server (I/O layer)** from the **core analysis logic**, allowing for optimized performance and scalability. This ensures that the tool can provide rapid diagnostics without compromising accuracy or performance

3. Recommendations

4. Process

5. Reading Guide

This section aims to provide a comprehensive overview of all the that was done and produced throughout the entire internship.

5.1 Professional Products

This section links to the professional products, and describes which learning outcome they contribute to and why.

5.1.1 Project plan (local)

Learning Outcomes Addressed:

- Professional Duties
- Future-Oriented Organisation
- Investigative Problem Solving
- Personal Leadership
- Targeted Interaction

Initiating and Defining the Project Scope:
At the start of the project, I recognized gaps in my understanding of the intent and requirements. This led me to proactively engage with stakeholders, including Romijn M. and Brandt J., and arrange a meeting with my company mentor and Romijn M. Through this initiative, I clarified the project scope and refined the expectations. The notes for this meeting can be found here.This demonstrates **Targeted Interaction** through stakeholder engagement and **Personal Leadership** in taking ownership of unclear requirements and clarifying them.

Structured Research Approach:
I aligned my research activities with the HBO-ICT research framework, selecting appropriate patterns and methods for each sub-question. This structured approach reflects **Future-Oriented Organisation** by ensuring a methodical and sustainable research process, and **Investigative Problem Solving** through evaluation of research methods best suited to the question.

Iterative Development and Feedback Application:
The project plan underwent four iterations. For each, I actively sought feedback from stakeholders and integrated their suggestions to improve the plan. While the final version was delivered within the available time constraints, I noted areas for future improvement, showing my ability to balance quality with deadlines. This iterative process showcases **Professional Duties** through delivering professional-grade documentation, **Targeted Interaction** by effectively communicating and integrating feedback, and **Personal Leadership** in evaluating and accepting constructive criticism.

5.1.2 User Requirements Specification (local)

Learning Outcomes Addressed:

- Professional Duties
- Situation orientation
- Future-Oriented Organisation

Building on Quality Requirements:
The user requirement specification formalizes the functional (FR) and non-functional requirements (NFR) identified during the project planning phase. By adopting user stories and acceptance criteria, I ensured the requirements were both specific and measurable. This demonstrates **Professional Duties** by creating a professional-grade deliverable, essential for guiding development.

Use of Known Techniques:
I utilized established techniques like user stories and acceptance criteria to structure requirements in a way that ensures clarity and aligns with best practices. This approach reflects my ability to apply known methodologies effectively in new contexts, showcasing **Situation-Oriented** skills.

Incorporating Stakeholder Feedback:
Through regular demonstrations and discussions with my company mentor, I refined and expanded the requirements and acceptance criteria based on their input. For example, adjustments were made to ensure alignment with users expectations; multiple fallbacks were determined for the positioning of diagnostics. This iterative collaboration exemplifies **Targeted Interaction**, where communication with stakeholders helped refine requirements and ensure they align with user's expectations.

Formalizing Requirements:
The specification was structured to include:

- **Non-Functional Requirements:** Constraints and quality attributes (e.g., coverage, performance).
- **Functional Requirements:** Clearly defined user stories that outline the desired behaviour.
    - **Acceptance Criteria:** Where applicable, further specification of the expected functionality.

Agile Workflow Integration:
Once defined, the user stories were included in the agile board, integrating them with the sprint-based development approach. This step highlights my ability to bridge planning with execution while ensuring visibility.

5.1.3 Software Architecture (local)

Learning Outcomes Addressed:

- Professional Duties
- Situation orientation
- Future-Oriented Organisation
- Investigative Problem Solving
- Targeted Interaction

Architectural Decisions and Documentation:
Throughout the project, I documented big architectural decisions using the MADR (Markdown Architectural Decision Records) template, as detailed in the ADRs. This approach ensured and a clear and defensible rational for each decision, exemplifying **Professional Duties** and **Investigative Problem Solving** by applying industry-recognized practices and conducting thorough evaluations of alternatives.

Use of Standardized Models:
The architecture was visualized using the C4 model, supported by sequence diagrams and additional diagrams where needed. This adherence to industry standards ensured that the design was clear, communicable, and easily understandable for stakeholders, reflecting **Professional Duties** and **Situation Orientation** by adapting to the audiences' expectations.

Guiding Principles:
The architecture design was guided by the project's non-functional requirements (e.g., IDE independence, seamless integration, real-time validation). These constraints were come from the User Requirements Specification and aligned with stakeholder needs, showcasing **Future-Oriented Organisation** by considering scalability and maintainability.

Iterative Updates:
The architecture evolved alongside the project, with incremental updates to reflect changes in scope and features. This continuous alignment with the project illustrates **Future-Oriented Organisation** ensuring that the architecture remained relevant and effective.

Stakeholder Collaboration:
I regularly presented architectural decisions and diagrams to stakeholders for feedback, adapting designs based on their input. The initial idea do add future extensions within the diagrams, came from them. This demonstrates **Situation Orientation** and **Targeted Interaction**, ensuring the architecture aligned with stakeholder expectations and projects' goals.

5.1.4 Survey Report (local)

Learning Outcomes Addressed:

- Professional Duties
- Targeted Interaction
- Investigative Problem Solving
- Personal Leadership

Objective and Approach:
The survey aimed to identify and prioritize problematic features in Azure Pipelines to guide the development of a diagnostic tool. To make the questions clearer, I added links to official documentation for each feature, ensuring accessibility and usability for participants. This demonstrates **Professional Duties** and **Targeted Interaction** by creating a thoughtful and professional survey.

When responses were slow, I adapted my approach by searching for additional relevant Slack channels and asking colleagues directly to fill out the survey. This flexibility and effort to engage participants reflect **Targeted Interaction** and **Personal Leadership**, as I focused on encouraging collaboration to achieve the project's goals.

Feedback and Analysis:
I sought feedback on the survey design and noted suggestions for future improvement, even if I didn't apply them immediately, showing **Professional Duties** by maintaining a continuous improvement mindset. After collecting responses, I used a weighted scoring method to rank features based on severity, frequency, and proficiency. Going beyond the rankings, I analysed the data to develop actionable recommendations, demonstrating **Investigative Problem Solving** by identifying root causes and proposing actionable solutions.

Collaboration:
Throughout the process, I incorporated feedback from stakeholders to ensure the report's relevance and clarity, showcasing **Targeted Interaction**.

5.2 Additional Activities

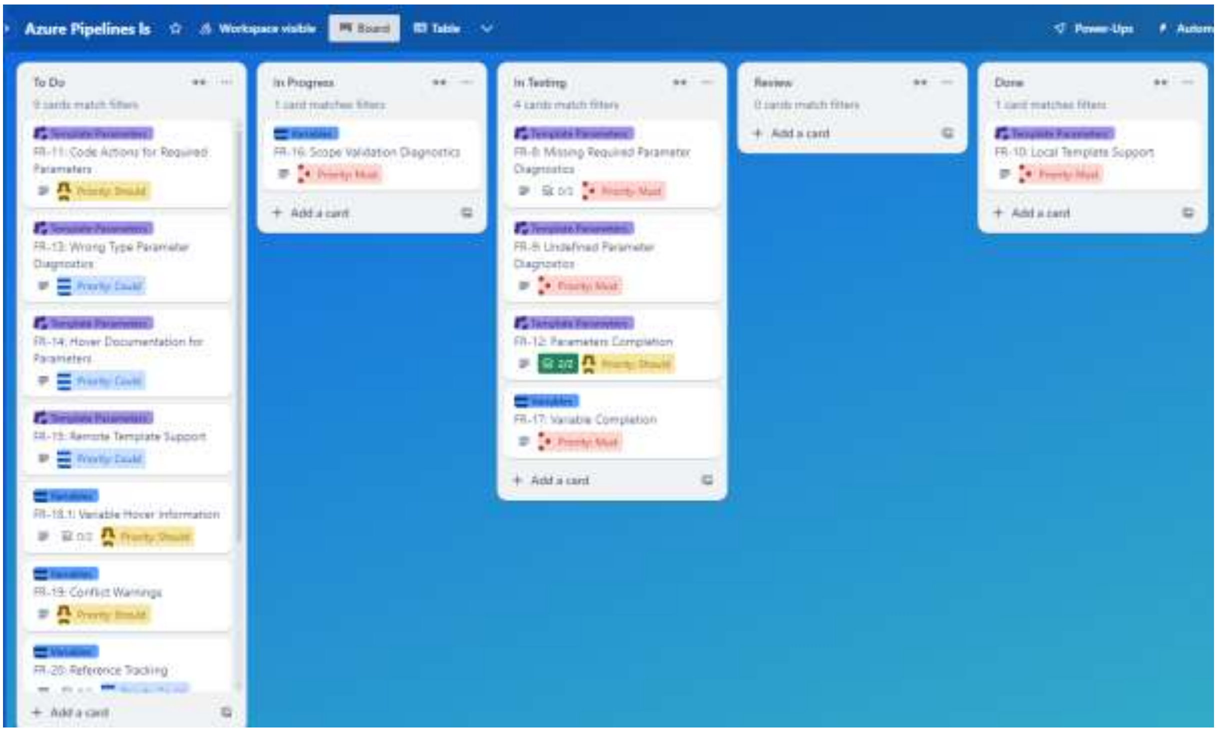
5.2.1 Kanban board

Learning Outcomes Addressed:

- Future-Oriented Organisation

To manage tasks throughout the project, I used a Trello Kanban board structured with columns: "To Do," "In Progress," "In Testing," "Review," and "Done," as outlined in the project plan. This setup allowed me to track progress, prioritize tasks, and ensure that work flowed efficiently through each phase.

Using this board helped me stay organized and adapt to changing priorities, demonstrating **Future-Oriented Organisation.**



5.2.2 Progress Update Meetings

Learning Outcomes Addressed:

- Targeted Interaction
- Professional Duties

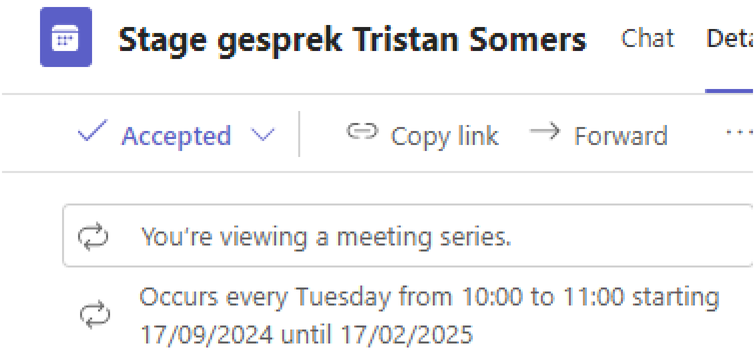
Throughout the project, I participated in regular progress update meetings, as outlined in the project plan. These included:

- **Weekly meetings with my first company mentor:** These provided consistent guidance and ensured alignment with the project's goals.

- **Bi-weekly meetings with my second company mentor:** These decreased in frequency as the project progressed and became less necessary, reflecting the project's steady development.

- **Weekly meetings with my first assessor:** These discussions focused on project progression, challenges, and ensuring alignment with Fontys expectations. These meetings also included another student, allowing us to compare progress, share advice, and support each other's development.

These meetings helped maintain clear communication with stakeholders, incorporate feedback into my work, and ensure the project would not go off track. The collaborative aspect of the assessor meetings shows **Targeted Interaction**, while consistent reporting and accountability demonstrate **Professional Duties**.



5.2.3 Company Training

Learning Outcomes Addressed:

- Professional Duties
- Investigative Problem Solving
- Personal Leadership

At the start of my internship, I had no prior experience with Azure DevOps. To address this my company mentor suggested I follow training, thus I proactively searched for and enrolled in a two-day training course offered by Info Support: **Azure DevOps Engineer (AZ-400)**. This course provided a solid foundation in Azure DevOps concepts and practices, allowing me to better understand the context around the project..

Taking the initiative to identify and fill this knowledge gap demonstrates **Personal Leadership**, as I took responsibility for my professional growth. The training also reflects **Investigative Problem Solving**, as it directly addressed a challenge that could have impacted my ability to succeed in the project. Furthermore, it highlights **Professional Duties**, as I ensured I had the necessary skills to meet the expectations of my role.

5.3 Learning Outcomes

This section provides a mapping from learning outcome to the evidence where it is displayed.

Learning Outcome	**Evidence**
Professional duties	Project plan (local) User Requirements Specification (local) Software Architecture (local) Survey Report (local) Progress Update Meetings Company Training
Situation-Orientation	User Requirements Specification (local) Software Architecture (local)
Future-Oriented Organisation	Project plan (local) User Requirements Specification (local) Software Architecture (local) Kanban Board
Investigative Problem Solving	Project plan (local) Software Architecture (local) Survey Report (local) Company Training
Personal Leadership	Project plan (local) Survey Report (local) Company Training
Targeted Interaction	Survey Report (local) Software Architecture (local) Project plan (local) Progress Update Meetings

6. Evaluation and Reflection