

# Automated Road Segmentation for Change Detection in Cologne: Project Overview & Characteristics

## 1 Document version

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Table 1: Document version

| Nr. | Date       | Version | Altered chapters | Type of altering | Author       |
|-----|------------|---------|------------------|------------------|--------------|
| 1   | 31.03.2023 | 1.1     | all              | Creation         | Adian Dawuda |
| 2   | 15.04.2023 | 1.2     | 6.5              | Update           | Adian Dawuda |
| 3   | 30.04.2023 | 1.3     | 6.5              | Update           | Adian Dawuda |
| 4   | 15.05.2023 | 1.4     | 6.5              | Update           | Adian Dawuda |
| 5   | 31.05.2023 | 1.5     | 2, 6.5, 6.6      | Update           | Adian Dawuda |
| 6   | 15.06.2023 | 1.6     | 6.5, 6.6         | Update           | Adian Dawuda |
| 7   | 30.06.2023 | 1.7     | 6.5, 6.6         | Update           | Adian Dawuda |

## 2 Project information

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Table 2: Overall project information

| Project |   |            |      |            |
|---------|---|------------|------|------------|
| Title   | Automated Road Segmentation for Change Detection in Cologne |            |      |            |
| Acronym | RChan   |            |      |            |
| Period  | Start:  | 07.03.2023 | End: | 30.06.2023 |

### 3 Project Content and Project Goals

Table 3: Project Content and Project Goals

| Content & Goals   |
|---|
| <b>Project description</b> (~100-150 words) <p>Through research and growingly accessible computing power, deep learning has emerged as a promising approach to extract information from images. This project aims to perform a change detection analysis on specific sections of the road network in Cologne, Germany using a U-Net architecture-based convolutional neural network (CNN) to generate binary semantic segmentation masks of roads from aerial images. The change detection will be between 1998 and 2019. The U-Net model is trained on an openly available dataset of roads in the state of Massachusetts. The test set for Cologne must be created, as no such dataset currently exists. The accuracy and ease of semantic segmentation for the change detection analysis are evaluated. The model is built using the TensorFlow framework and interacts with the imagery data in a Python environment. The processes and findings of this project are outlined in this paper. The code and pre-trained model are available on GitHub and GitLab.</p> |
| <b>Project purpose, benefits and target group description</b> (~100 words) <p>The project will display the use of deep learning for automatically processing and retrieving information from the large and growing amount of Earth Observation (EO) data that is being created. Automating laborious and manually time-consuming mapping tasks such as road mapping has great potential to improve work efficiency and resource allocation. As the model is trained on a dataset of a different area than the final test set, the model's generalization capabilities are tested. Given the interdisciplinary application domains of image understanding and change detection, this project may provide valuable findings for a broad range of actors and contributes to the growing field of earth observation and deep learning.</p>  |
| <b>Project objectives</b> (please also include a listing of the sub-goals) (~100 words) <ul style="list-style-type: none"> <li>- To apply a change detection of selected areas of the road network in Cologne</li> <li>- To conduct automated semantic segmentation using deep learning (Extraction of roads from aerial images) <ul style="list-style-type: none"> <li>↔ To build a U-Net CNN and successfully pre- and postprocess images for the model</li> </ul> </li> <li>- To write an IMRAD style paper outlining the project</li> <li>- To publish and present the findings</li> </ul>  |
| <b>Non-Goals</b> <p>Creating a broad multi-purpose model. Creating multiple final models. Conducting in depth change detection for the whole of Cologne. General analysis of deep learning methods and approaches.</p>  |

## 4 Frame of the project

Table 4: Frame of the project – Part 1

| Context  |
|--|
| <b>Up-to-date status</b> (~50-100 words)   |
| The overall project is currently in its early stages. The literature review phase is ongoing and the methodology is largely finalized. The training data, consisting of aerial images has been acquired. The test dataset of Cologne is currently being created.   |
| <b>Project setting</b> (~50 Wörter)  |
| The project is being conducted during the summer semester of 2023 in the <i>I3 Project</i> course in the M.Sc. Applied geoinformatics curriculum. Over the course of the semester, a total of 300 hours is to be spent working on the project. Of these 300 hours, the course seminar takes up 4 hours per week. |

Table 5: Frame of the project – Part 2

| Time frame of the project |            |   |            |
|---------------------------|------------|---|------------|
| <b>Start:</b>             | 07.03.2023 | <b>End:</b>   | 30.06.2023 |
| <b>Important Dates</b>    |            |   |            |
| 1                         | 07.03.2023 | Kick-off  |            |
| 2                         | 09.04.2023 | Milestones: Understanding of RChan's position among the state-of-the-art development. Methodology approach finalized. Computing environment selected. |            |
| 3                         | 09.05.2023 | Pecha Kucha presentation  |            |
| 4                         | 04.06.2023 | WP 5 complete and final results ready   |            |
| 5                         | 20.06.2023 | Final poster presentation   |            |
| 6                         | 30.06.2023 | Project completion (Paper submission)   |            |

## 5 Resources & Budget

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Table 6: Resources and Budget – Part 1

|                     |
|---------------------|
| <b>Project Team</b> |
| <b>Project Lead</b> |
| Adian Dawuda        |
| <b>Project Team</b> |
| Adian Dawuda        |

Table 7: Resources and Budget – Part 2

|                       |
|-----------------------|
| <b>Resources</b>      |
| <b>Personal costs</b> |
| ---                   |
| <b>Project costs</b>  |
| ---                   |
| <b>Other Costs</b>    |
| —                     |

## 6 Project structure, description and risk matrix

### 6.1 Work packages overview

Table 8: Work packages overview

| WP | Name of the Work Package        | Time Frame [from – to]  |
|----|---------------------------------|-------------------------|
| 1  | Project Management              | 07.03.2023 – 30.06.2023 |
| 2  | Literature Review & Methodology | 07.03.2023 – 09.04.2023 |
| 3  | Data Aquisition                 | 13.03.2023 – 16.04.2023 |
| 4  | Data Analysis                   | 27.03.2023 – 07.05.2023 |
| 5  | Testing, Evaluation, Validation | 08.05.2023 – 04.06.2023 |
| 6  | Dissemination                   | 24.04.2023 – 25.06.2023 |

### 6.2 Work Breakdown Structure (WBS)

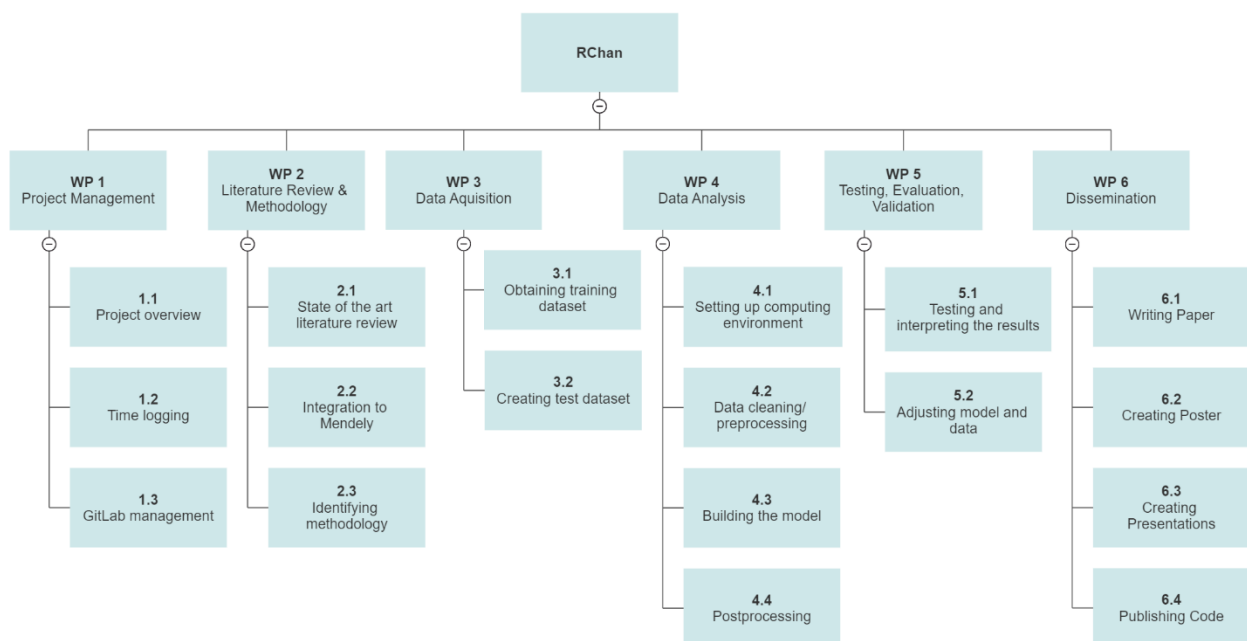


Figure 1 Work breakdown Structure

## 6.3 Detailed work plan

Table 9: Detailed Work Plan – WP1

| WP 1   | Project management | Duration | 07.03.2023 – 30.06.2023 |
|--|--------------------|----------|-------------------------|
| Project Lead   | Project team       |          |                         |
| Adian Dawuda   | Adian Dawuda       |          |                         |
| Objectives   |                    |          |                         |
| To Manage all aspects of the project (including Gitlab) and keep track of progress and time. |                    |          |                         |
| Content & Tasks  |                    |          |                         |
| 1.1: To regularly update project overview and time sheet                                     |                    |          |                         |
| 1.2: To update GitLab (at least bi-weekly)   |                    |          |                         |
| Expected results   |                    |          |                         |
| Up to date information of the project's status.  |                    |          |                         |
| Milestones & Deliverables  |                    |          |                         |
| D1: Project overview documents   |                    |          |                         |
| D2: GitLab Wiki and repository entries   |                    |          |                         |

Table 10: Detailed Work Plan – WP1

| WP 2   | Literature Review & Methodology | Duration     | 07.03.2023 – 09.04.2023 |
|--|---------------------------------|--------------|-------------------------|
| Project Lead   |                                 | Project team |                         |
| Adian Dawuda   |                                 | Adian Dawuda |                         |
| Objectives   |                                 |              |                         |
| To find and catalogue relevant literature and gain a good understanding of the state of the art for image segmentation/change detection. To identify the methodology to be used. |                                 |              |                         |
| Content & Tasks  |                                 |              |                         |
| 2.1: State of the art literature review<br>2.2: Integration to Mendely<br>2.3: To identify methodology (including choosing the model architecture)                               |                                 |              |                         |
| Expected results   |                                 |              |                         |
| Catalogue of citable literature and overview of the state of the art leading to a clearly identified methodology.  |                                 |              |                         |
| Milestones & Deliverables  |                                 |              |                         |
| M1: Understanding of the project's position among the state-of-the-art development.<br>M2: Selected methodology approach<br>D1: Catalogue of citable literature                  |                                 |              |                         |

**Table 11: Detailed Work Plan – WP2**

| WP 3  | Data Acquisition | Duration     | 13.03.2023 – 16.04.2023 |
|---|------------------|--------------|-------------------------|
| Project Lead  |                  | Project team |                         |
| Adian Dawuda  |                  | Adian Dawuda |                         |
| Objectives  |                  |              |                         |
| To obtain and create all the necessary data for conducting the project (Train and Test images). |                  |              |                         |
| Content & Tasks   |                  |              |                         |
| 3.1: Obtaining training dataset<br>3.2: Creating test dataset (Cologne)                         |                  |              |                         |
| Expected results  |                  |              |                         |
| Training and testing dataset of aerial images and their corresponding ground truth masks.       |                  |              |                         |
| Milestones & Deliverables   |                  |              |                         |
| D1: Training dataset<br>D2: Test dataset  |                  |              |                         |

**Table 12: Detailed Work Plan – WP3**

| WP 4  | Data Analysis | Duration     | 27.03.2023 – 07.05.2023 |
|---|---------------|--------------|-------------------------|
| Project Lead  |               | Project team |                         |
| Adian Dawuda  |               | Adian Dawuda |                         |
| Objectives  |               |              |                         |
| To build and apply a functioning U-Net deep learning model for road segmentation.   |               |              |                         |
| Content & Tasks   |               |              |                         |
| 4.1: Setting up computing environment<br>4.2: Data cleaning/preprocessing<br>4.3: Building the model<br>4.4: Postprocessing                   |               |              |                         |
| Expected results  |               |              |                         |
| A deep learning model that can read input images perform segmentation and output the segmented images.<br>First results.                      |               |              |                         |
| Milestones & Deliverables   |               |              |                         |
| M1: Adequate computing environment selected<br>D1: Cleaned dataset/preprocessing code<br>D2: U-Net CNN model<br>D3: Image postprocessing code |               |              |                         |



Table 13: Detailed Work Plan – WP4

| WP 5   | Testing, Evaluation, Validation | Duration     | 08.05.2023 – 04.06.2023 |
|--|---------------------------------|--------------|-------------------------|
| Project Lead   |                                 | Project team |                         |
| Adian Dawuda   |                                 | Adian Dawuda |                         |
| Objectives   |                                 |              |                         |
| To test and evaluate the performance of the model. To apply changes to the model/input/hyperparameters to improve the performance. To repeat these steps and finetune the model. |                                 |              |                         |
| Content & Tasks  |                                 |              |                         |
| 5.1: Testing and interpreting<br>5.2: Adjusting model and data   |                                 |              |                         |
| Expected results   |                                 |              |                         |
| A finetuned model, delivering better results than before this step.  |                                 |              |                         |
| Milestones & Deliverables  |                                 |              |                         |
| M1: Numerous milestones for improving the model<br>D1: Final model delivering the best results (many previous iterations also deliverables)                                      |                                 |              |                         |

Table 14: Detailed Work Plan – WP5

| WP 6  | Dissemination | Duration     | 24.04.2023 – 25.06.2023 |
|---|---------------|--------------|-------------------------|
| Project Lead  |               | Project team |                         |
| Adian Dawuda  |               | Adian Dawuda |                         |
| Objectives  |               |              |                         |
| To write the paper describing the project comprising Introduction, Methods, Results and Discussion parts. To create two presentations. To publish the code used for the analysis. |               |              |                         |
| Content & Tasks   |               |              |                         |
| 6.1: Writing paper<br>6.2: Creating poster<br>6.3: Creating presentations<br>6.4: Publishing code   |               |              |                         |
| Expected results  |               |              |                         |
| An IMRAD-style paper of the project. Final poster and Pecha Kucha presentations. Cleaned and commented code used for the analysis.  |               |              |                         |
| Milestones & Deliverables   |               |              |                         |
| D1: The paper of the project<br>D2: Poster of the project<br>D3: Pecha Kucha and final Presentations<br>D4: Code used for the project   |               |              |                         |

## 6.4 Milestone plan

Table 15: Milestone plan

| MS | Name  | Date Completion |
|----|---|-----------------|
| M1 | Understanding of RChan's position among the state-of-the-art development.     | 09.04.2023      |
| M2 | Selected methodology approach   | 09.04.2023      |
| M3 | Adequate computing environment selected                                       | 09.04.2023      |
| M4 | Numerous improvement milestones during the Testing, Evaluation, Validation WP | 04.06.2023      |

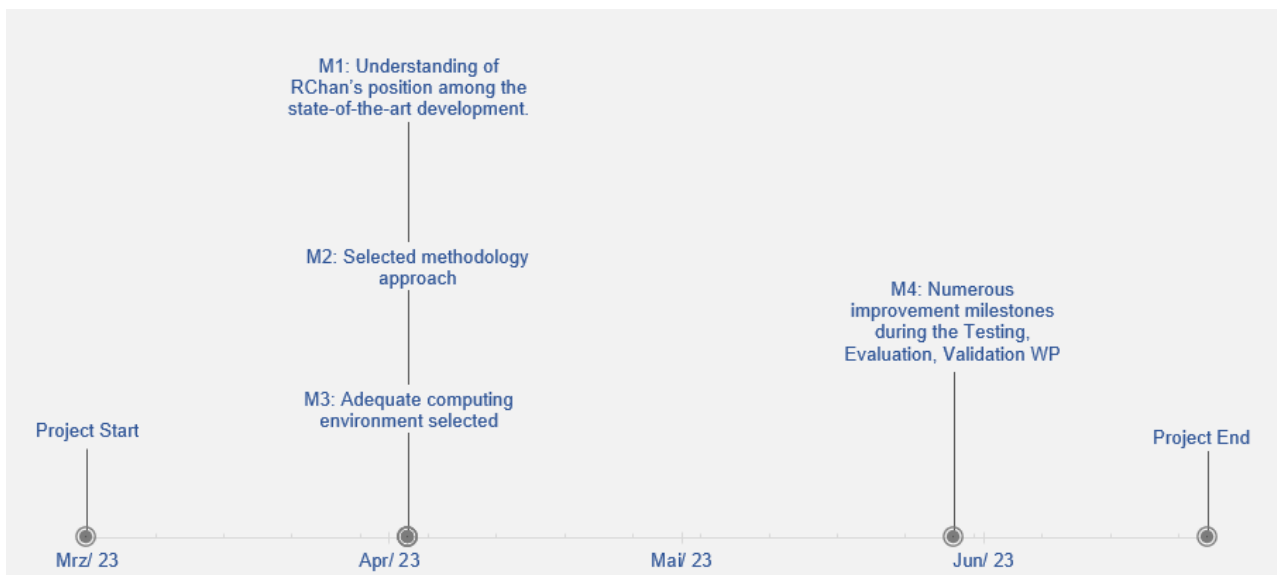


Figure 2 Milestones

## 6.5 Gantt Chart

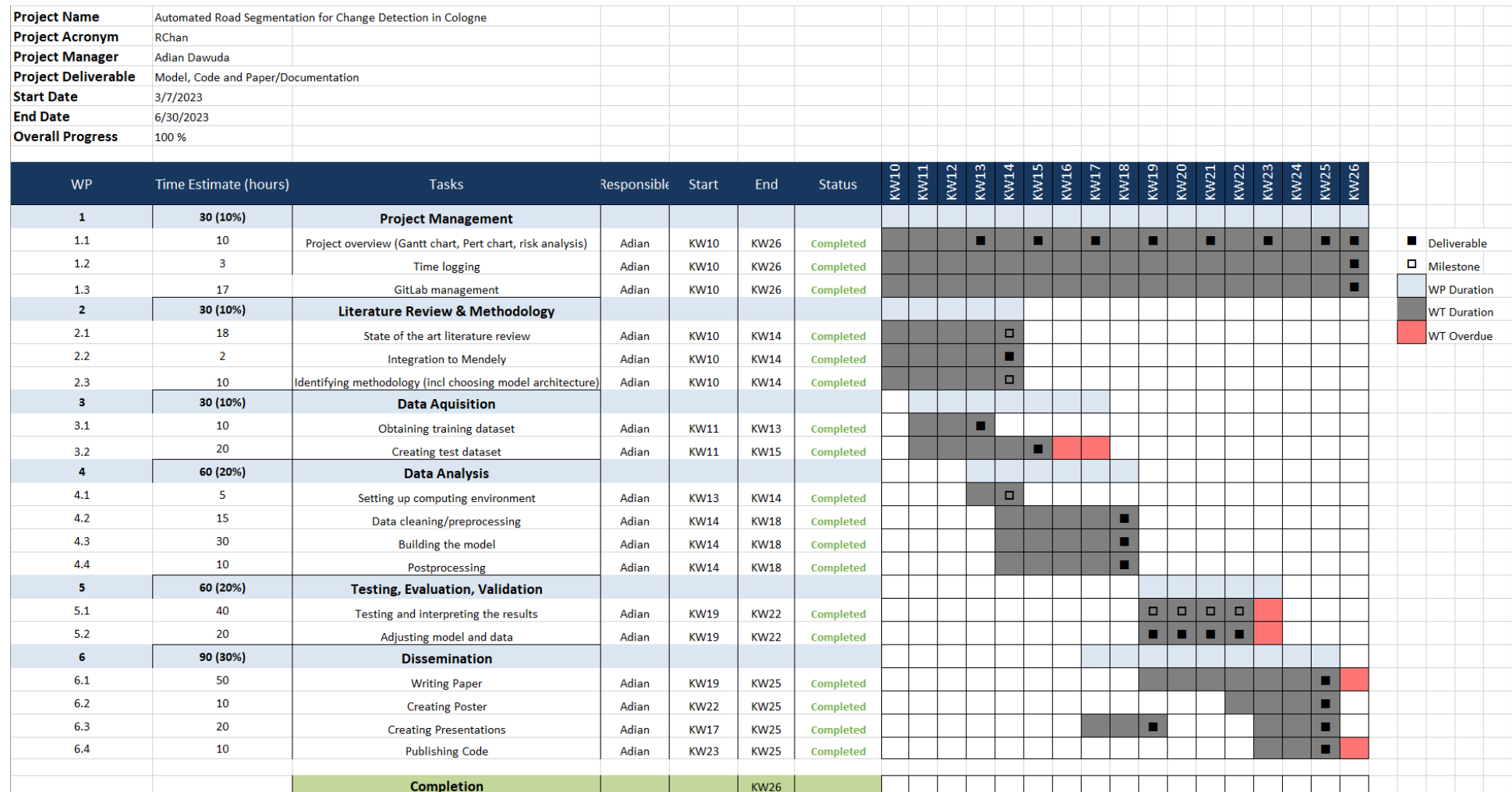


Figure 3 Gantt Chart

## 6.6 Risk Matrix

Table 16: Risk matrix

| No | Risk   | Potential adverse impact   | Risk level* | Risk management strategy   | Responsibility |
|----|--|--|-------------|--|----------------|
| 1  | Cannot obtain training dataset.  | Bad performance of the model due to lacking/unsuitable training data or no model at all. | C           | Research available datasets.   | Adian Dawuda   |
| 2  | Cannot find/create test dataset.   | Cannot conduct change detection of Cologne road network.                                 | C           | Early research of available datasets and or availability of necessary data for dataset creation.   | Adian Dawuda   |
| 3  | Problems with Google Collab (denied access, servers down).   | No access to computing environment -> cannot develop or test model.                      | C           | Local computing environment or Google Collab alternatives (e.g., Azure Notebook).  | Adian Dawuda   |
| 4  | Coding problems or errors that hinder the development of a functioning workflow (e.g., cannot read images, model does not compile or predict masks). | Inability to perform the desired analysis.   | C           | Small errors often occur and are mostly easily fixable. Looking up common problems on the internet may provide solutions. Peers or members of the department could be asked for help in extreme cases. | Adian Dawuda   |
| 5  | Underestimation of tasks (time).   | Late project completion.   | C           | Continuous project management to keep track of the project's progress and status. Well thought out time plan with one week of additional buffer planned.   | Adian Dawuda   |

\*High (H), Medium (M), Low (L), Cleared (C)

**15.05. Risk 3:** No access to high ram & GPU runtime because of Colab Pro payment problems -> Should be fixed before KW24 at the latest.

**10.06. Risk 3:** Problem solved

# 7 Additional comments

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Table 17: Additional comments

| Comments |
|----------|
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# 8 Approval

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Table 18: Approval

| Freigabe                         |  |                                   |  |
|----------------------------------|--|-----------------------------------|--|
| Date: ---                        |  | Date: ---                         |  |
| —                                |  | —                                 |  |
| Signature principal investigator |  | Signature project lead/contractor |  |

## 9 Attachments

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*Attachment 1: Gantt chart (biweekly updated).*