# Sheet Metal Client Hub Design Document

*Document Title: Design Document*

*Date: 1 May 2025*

*Prepared by: Laurie Moffat*

*Course: PDSWD7 PDA in Software Development Level 7, Fife College, Semester 1, 2024/25*

## Introduction

This Design Document outlines the system architecture and specifications for the Sheet Metal Client Hub, a Python-based desktop application for automating cost calculations and basic quote generation for sheet metal parts. It follows the Project Charter and Development Plan in the Waterfall SDLC, providing detailed designs for the Tkinter GUI, cost calculation logic, and file I/O, to be implemented in the Development phase (26 April – 20 May 2025). The design aligns with the Project Charter to mitigate scope creep, focusing on core functionality for a functional prototype.

## System Overview

The application will feature:

1. A Tkinter GUI with screens for login, part input, cost output, quote generation, and settings.
2. Cost calculations for 10 work centres (cutting, bending, welding, deburring, assembly, inspection, surface treatment, machining, forming, fastening).
3. Support for part specifications, including single parts or assemblies (with weldments as a specific case), material thicknesses (1, 1.2, 1.5, 2, 2.5, 3 mm), lay-flat dimensions (50-3000 mm length, 50-1500 mm width), revision levels for quality control, and work centre-specific parameters.
4. Basic quote generation with customer name, quote number, date, profit margin, and text-based output.
5. File I/O for user credentials (data/users.txt), global rates (data/rates\_global.txt), calculation results (data/output.txt), and quotes (data/quotes.txt).

## Functional Requirements

* **FR1:** The system allows users to log in with a username and password stored in data/users.txt.
* **FR2:** The system shall enable users to input ***part specifications***, including part type (Single Part/Assembly), part number (unique string, format PART-[5-15 alphanumeric]), revision level (alphanumeric, format Rev [A-Z0-9]{1-5}), material, thickness (1, 1.2, 1.5, 2, 2.5, 3 mm), lay-flat dimensions (50-3000 mm length, 50-1500 mm width), and batch quantity (1-1000), with additional work centre-specific parameters as defined in FR2.1 to FR2.10. For Single Parts, users input parameters directly; for Assemblies, users input an assembly part number, revision level, top-level assembly (string, format ASSY-[5-15 alphanumeric]), weldment indicator (Yes/No), and a list of up to 10 component sub-parts, each with its own part number, revision level, and specifications per FR2.1 to FR2.10, to support cost calculations for all 10 work centres (cutting, bending, welding, deburring, assembly, inspection, surface treatment, machining, forming, fastening) and customer-specific bulk quoting with revision control, with results used in FR7 for quote generation.
* **FR2.1:** The system enables users to input ***cutting specifications***, including cutting method (Laser Cutting/Turret Press Punching/None) and cutting complexity (1-10, mandatory if cutting method is not None), to calculate cutting costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.2:** The system shall enable users to input ***bending specifications***, including bends (0-20), to calculate bending costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.3:** The system shall enable users to input ***welding specifications***, including weld length (0-5000 mm, optional), weld type (None/MIG/TIG, mandatory if weld length > 0), and weld quality (Standard/High, mandatory if weld length > 0), to calculate welding costs based on user-defined rates for each weld type and quality in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt. For Assemblies with weldment indicator set to Yes, welding parameters are prioritized in the input process, and revision levels ensure alignment with the latest design specifications.
* **FR2.4:** The system shall enable users to input ***deburring specifications***, including deburring intensity (None/Light/Heavy), to calculate deburring costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.5:** The system shall enable users to input ***assembly specifications*** for parts identified as Assemblies (part type is Assembly), including an assembly part number (unique string, format PART-[5-15 alphanumeric]), revision level (alphanumeric, format Rev [A-Z0-9]{1-5}), top-level assembly (string, format ASSY-[5-15 alphanumeric]), weldment indicator (Yes/No), a list of up to 10 component sub-parts (each with its own part number, revision level, and specifications per FR2.1 to FR2.4 and FR2.6 to FR2.10), assembly components (0-50, optional), and assembly sequence (0-10, optional), to calculate assembly costs by summing sub-part costs (calculated per FR2.1 to FR2.4 and FR2.6 to FR2.10, with emphasis on welding costs for weldments) and adding assembly-specific costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, adjusted by an assembly complexity factor, with results and revision levels stored in data/output.txt for use in FR7 quote generation.
* **FR2.6:** The system shall enable users to input ***inspection specifications***, including inspection scope (None/Standard/Comprehensive) and inspection points (0-50, optional), to calculate inspection costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.7:** The system shall enable users to input ***surface treatment specifications***, including surface treatment type (None/Painting/Coating) and surface treatment coverage (None/Partial/Full, mandatory if type is not None), to calculate surface treatment costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.8:** The system enables users to input ***machining specifications***, including machining operations (0-20, optional) and machining precision (None/Standard/High, mandatory if operations > 0), to calculate machining costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.9:** The system shall enable users to input ***forming specifications***, including forming steps (0-10, optional) and forming complexity (None/Low/Medium/High, mandatory if steps > 0), to calculate forming costs based on user-defined rates in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR2.10:** The system shall enable users to input ***fastening specifications***, including fastener types and counts (list of [type: Bolts/Rivets/Screws, count: 0-100], optional, at least one type required if any count > 0), to calculate fastening costs based on user-defined rates for each fastener type in data/rates\_global.txt or data/rates\_<username>.txt, with results stored in data/output.txt.
* **FR3:** The system shall calculate costs for parts based on specifications and user-defined rates from data/rates\_global.txt or data/rates\_<username>.txt, adjusting costs based on work centre-specific parameters, with results and revision levels stored in data/output.txt.
* **FR4:** The system shall display calculated costs in an output screen, showing sub-part costs and revision levels for Assemblies.
* FR5: The system shall save calculation results, including part number, revision level, top-level assembly, sub-part details (for Assemblies), fastener types, and batch quantity, to data/output.txt.
* **FR6:** The system shall allow users to manage rates for each work centre and parameter (e.g., laser cutting, MIG welding, bolts) in a settings screen.
* **FR7:** The system shall enable users to generate customer-specific quotes by inputting customer name, quote number (auto-generated, format QUOTE-[YYYY]-[0-9]{3}), quote date (auto-set to current date), and profit margin (percentage), with optional inputs for customer contact, project reference, validity period, quote terms, overhead rate, discount, delivery timeframe, and delivery location, and combining these with part specifications and cost calculations from FR2 to produce a text-based quote stored in data/quotes.txt. The quote shall include customer name, quote number, quote date, part/assembly details (part number, revision level, sub-parts for assemblies, work centre specifications), cost breakdown (per work centre, sub-part costs, subtotal, margin, total price in GBP), and optional fields if provided, with the cost breakdown displayed on the output screen.

## Non-Functional Requirements

* **NFR1:** The GUI shall respond to user inputs within 1 second under normal conditions.
* **NFR2:** The system shall support at least 100 concurrent user profiles in data/users.txt.
* **NFR3:** The system shall ensure secure storage of user credentials with basic encryption or hashing.
* **NFR4:** The application shall be compatible with Windows 10 and Python 3.9.
* **NFR5:** The GUI shall be intuitive, requiring no more than 5 minutes of training for new users.

## Data Dictionary

The following table defines the data fields used in the system:

|  |  |  |  |
| --- | --- | --- | --- |
| Field | *Type* | *Description* | *Constraints* |
| **part\_type** | String | Indicates if the input is a single part or an assembly | Mandatory, must be "Single Part" or "Assembly" |
| **part\_number** | String | Unique identifier for the part or assembly | Mandatory, format PART- [5-15 alphanumeric characters], no spaces |
| **revision\_level** | String | Engineering design revision level | Mandatory, format Rev [A-Z0-9] {1-5}, max 9 characters including "Rev " |
| **weldment\_indicator** | String | Indicates if the assembly is a weldment | Mandatory for part\_type = "Assembly", must be "Yes" or "No", disabled for Single Part |
| **top\_level\_assembly** | String | Identifier for the parent assembly | Mandatory for part\_type = "Assembly", format ASSY-[5-15 alphanumeric], no spaces |
| **sub\_parts** | List of Part Specifications | List of up to 10 component sub-parts for Assemblies | Mandatory for part\_type = "Assembly", max 10 sub-parts, each with unique part\_number and revision\_level |
| **material** | String | Material type | Selected from predefined list |
| **thickness** | Float | Material thickness in mm | Must be one of 1, 1.2, 1.5, 2, 2.5, 3 |
| **length** | Float | Lay-flat length in mm | 50 <= length <= 3000 |
| **width** | Float | Lay-flat width in mm | 50 <= width <= 1500 |
| **bends** | Integer | Number of bends in the part | 0 <= bends <= 20 |
| **cutting\_method** | String | Cutting process for the part | Mandatory, must be "Laser Cutting", "Turret Press Punching", or "None" |
| **cutting\_complexity** | Integer | Number of cuts or contour complexity | 1 <= cutting\_complexity <= 10 if cutting\_method is not None, otherwise 0 |
| **weld\_length** | Float | Weld length in mm | 0 <= weld\_length <= 5000, default 0 |
| **weld\_type** | String | Type of welding process | None, MIG, TIG; mandatory if weld\_length > 0, otherwise None |
| **weld\_quality** | String | Quality level of welding | Standard, High; mandatory if weld\_length > 0, otherwise None |
| **deburring\_intensity** | String | Intensity of deburring required | Mandatory, must be "None", "Light", or "Heavy" |
| **assembly\_components** | Integer | Number of components for assembly integration | 0 <= assembly\_components <= 50, default 0 |
| **assembly\_sequence** | Integer | Position in the assembly sequence | 0 <= assembly\_sequence <= 10, default 0 |
| **inspection\_scope** | String | Scope of inspection required | Mandatory, must be "None", "Standard", or "Comprehensive" |
| **inspection\_points** | Integer | Number of points or features inspected | 0 <= inspection\_points <= 50, default 0 |
| **surface\_treatment\_type** | String | Type of surface treatment | Mandatory, must be "None", "Painting", or "Coating" |
| **surface\_treatment\_coverage** | String | Coverage area for surface treatment | None, Partial, Full; mandatory if surface\_treatment\_type is not None |
| **machining\_operations** | Integer | Number of machining operations | 0 <= machining\_operations <= 20, default 0 |
| **machining\_precision** | String | Precision level for machining | None, Standard, High; mandatory if machining\_operations > 0, otherwise None |
| **forming\_steps** | Integer | Number of forming steps | 0 <= forming\_steps <= 10, default 0 |
| **forming\_complexity** | String | Complexity of forming | None, Low, Medium, High; mandatory if forming\_steps > 0, otherwise None |
| **fastener\_types\_and\_counts** | List of Tuples | List of fastener types and their counts | Optional, each type must be Bolts, Rivets, Screws or PEM fasteners, each count 0-100, at least one type required if any count > 0, default empty list |
| **batch\_quantity** | Integer | Number of identical parts or assemblies in a batch | Mandatory, 1 <= batch\_quantity <= 1000 |
| **customer\_name** | String | Name of the customer | Mandatory for quote generation, max 100 characters |
| **customer\_contact** | String | Customer contact details | Optional, max 100 characters |
| **project\_reference** | String | Customer project identifier | Optional, max 50 characters |
| **quote\_number** | String | Unique identifier for the quote | Mandatory, format QUOTE-[YYYY]-[0-9]{3}, auto-generated |
| **quote\_date** | Date | Date the quote is generated | Mandatory, auto-set to current date (e.g., 6 May 2025) |
| **validity\_period** | Integer | Number of days the quote is valid | Optional, 1 <= validity\_period <= 90, default 30 |
| **quote\_terms** | String | Terms or conditions for the quote | Optional, max 500 characters |
| **profit\_margin** | Float | Percentage markup on costs | Mandatory, 0 <= profit\_margin <= 100 |
| **overhead\_rate** | Float | Percentage for indirect costs | Optional, 0 <= overhead\_rate <= 50, default 0 |
| **discount** | Float | Percentage discount on total cost | Optional, 0 <= discount <= 50, default 0 |
| **delivery\_timeframe** | String | Estimated delivery timeframe | Optional, max 50 characters |
| **delivery\_location** | String | Customer delivery location | Optional, max 100 characters |

## Diagrams

### Gantt Chart (docs/diagrams/Gantt Chart.png):

Illustrates the project timeline (1 April – 2 June 2025).

### Use Case Diagram (docs/diagrams/Use\_Case\_Diagram.png):

Shows user interactions, including selecting part type, specifying revision levels, weldment indicator, inputting assembly sub-parts with welding parameters, and generating text-based quotes.

### Sequence Diagram (docs/diagrams/Sequence\_Diagram.png):

Details the part input and quote generation process, including revision level input, weldment indicator, sub-part specifications, and simplified quoting inputs/outputs.

### Structure Chart (docs/diagrams/Structure\_Chart.png):

Depicts modular organization (main.py, gui.py, calculator.py, file\_handler.py, tests).

### Class Diagram (docs/diagrams/Class\_Diagram.png):

Defines classes (App, Calculator, FileHandler) with updated attributes for revision levels and quoting.

### Data Flow Diagram (DFD) (docs/diagrams/DFD.png):

Shows data flow from input (including part type, revision level, weldment indicator, sub-parts) to output storage and quote generation.

### Entity-Relationship Diagram (ERD) (docs/diagrams/ERD.png):

Models User, Part, and Rate relationships, including sub-parts, revision levels, and welding parameters for weldments.

### State Diagram (docs/diagrams/State\_Diagram.png):

Shows GUI state transitions (Login, Part Input [Single Part/Assembly/Weldment], Quote Generation, Output).

### Activity Diagram (docs/diagrams/Activity\_Diagram.png):

Details the part input, cost calculation, and quote generation workflow for Single Parts and Assemblies, including weldments and revision control.

### Wireframes (docs/diagrams/Login\_Wireframe.png, Part\_Input\_Wireframe.png, Quote\_Generation\_Wireframe.png, Output\_Wireframe.png, Settings\_Wireframe.png):

Visualize GUI layouts with part type dropdown, revision level input, weldment indicator, sub-part input for Assemblies, and simplified quoting inputs.

## Pseudocode

### Pseudocode: Generate Quote

FUNCTION generate\_quote(part, batch\_quantity, customer\_info, quote\_metadata, cost\_modifiers)

INPUT part\_type, part\_number, revision\_level, weldment\_indicator, top\_level\_assembly, sub\_parts, material, thickness, length, width, batch\_quantity, work\_centre\_params, customer\_name, quote\_number, quote\_date, profit\_margin, customer\_contact, project\_reference, validity\_period, quote\_terms, overhead\_rate, discount

SET total\_cost = calculate\_cost(part, batch\_quantity)

SET subtotal = total\_cost

SET overhead = subtotal \* (overhead\_rate / 100)

SET margin = (subtotal + overhead) \* (profit\_margin / 100)

SET discount\_amount = (subtotal + overhead + margin) \* (discount / 100)

SET final\_price = subtotal + overhead + margin - discount\_amount

CREATE quote\_record AS TEXT

WRITE TO quote\_record:

CUSTOMER: customer\_name

QUOTE: quote\_number, quote\_date

PART\_DETAILS:

IF part\_type = "Single Part"

WRITE part\_number, revision\_level, material, thickness, length, width, batch\_quantity

ELSE

WRITE assembly\_part\_number, revision\_level, top\_level\_assembly, weldment\_indicator

FOR EACH sub\_part IN sub\_parts

WRITE sub\_part.part\_number, sub\_part.revision\_level

END FOR

END IF

COST\_BREAKDOWN:

FOR EACH work\_centre IN [cutting, bending, welding, deburring, assembly, inspection, surface\_treatment, machining, forming, fastening]

WRITE work\_centre, work\_centre\_cost

END FOR

IF part\_type = "Assembly"

FOR EACH sub\_part IN sub\_parts

WRITE sub\_part.part\_number, sub\_part\_cost

END FOR

END IF

WRITE Subtotal: subtotal

WRITE Overhead: overhead

WRITE Profit Margin: margin

WRITE Discount: discount\_amount

WRITE Total Price: final\_price

OPTIONAL\_FIELDS:

IF customer\_contact IS NOT EMPTY

WRITE Contact: customer\_contact

IF project\_reference IS NOT EMPTY

WRITE Project: project\_reference

IF validity\_period IS NOT EMPTY

WRITE Validity: validity\_period days

IF quote\_terms IS NOT EMPTY

WRITE Terms: quote\_terms

SAVE quote\_record TO data/quotes.txt

DISPLAY cost\_breakdown ON output\_screen

RETURN quote\_record

END FUNCTION

### Pseudocode: Calculate Cost

FUNCTION calculate\_cost(part, batch\_quantity)

INPUT part\_type, part\_number, revision\_level, weldment\_indicator, top\_level\_assembly, sub\_parts, material, thickness, length, width, batch\_quantity, work\_centre\_params

IF part\_type NOT IN ["Single Part", "Assembly"]

DISPLAY error: "Invalid part type"

RETURN

IF part\_number NOT MATCH "PART-[0-9a-zA-Z]{5,15}"

DISPLAY error: "Invalid part number format"

RETURN

IF revision\_level NOT MATCH "Rev [A-Z0-9]{1,5}"

DISPLAY error: "Invalid revision level format"

RETURN

IF part\_type = "Assembly" AND top\_level\_assembly NOT MATCH "ASSY-[0-9a-zA-Z]{5,15}"

DISPLAY error: "Invalid top-level assembly format"

RETURN

IF part\_type = "Single Part" AND top\_level\_assembly IS NOT EMPTY

DISPLAY error: "Top-level assembly not applicable for single part"

RETURN

IF part\_type = "Assembly" AND weldment\_indicator NOT IN ["Yes", "No"]

DISPLAY error: "Invalid weldment indicator"

RETURN

IF part\_type = "Assembly" AND sub\_parts IS EMPTY

DISPLAY error: "At least one sub-part required for assembly"

RETURN

IF part\_type = "Assembly" AND LENGTH(sub\_parts) > 10

DISPLAY error: "Maximum 10 sub-parts allowed"

RETURN

FOR EACH sub\_part IN sub\_parts

IF sub\_part.part\_number NOT MATCH "PART-[0-9a-zA-Z]{5,15}"

DISPLAY error: "Invalid sub-part number format"

RETURN

IF sub\_part.revision\_level NOT MATCH "Rev [A-Z0-9]{1,5}"

DISPLAY error: "Invalid sub-part revision level format"

RETURN

END FOR

IF thickness NOT IN [1, 1.2, 1.5, 2, 2.5, 3]

DISPLAY error: "Invalid thickness"

RETURN

IF length < 50 OR length > 3000

DISPLAY error: "Invalid length"

RETURN

IF width < 50 OR width > 1500

DISPLAY error: "Invalid width"

RETURN

IF batch\_quantity < 1 OR batch\_quantity > 1000

DISPLAY error: "Invalid batch quantity"

RETURN

READ rates FROM data/rates\_global.txt OR data/rates\_<username>.txt

SET total\_cost = 0

IF part\_type = "Single Part"

SET part\_cost = calculate\_single\_part\_cost(part, work\_centre\_params, rates)

MULTIPLY part\_cost BY batch\_quantity

MULTIPLY part\_cost BY batch\_discount\_factor(batch\_quantity)

ADD part\_cost TO total\_cost

ELSE IF part\_type = "Assembly"

SET assembly\_cost = 0

FOR EACH sub\_part IN sub\_parts

SET sub\_part\_cost = calculate\_single\_part\_cost(sub\_part, sub\_part.work\_centre\_params, rates)

ADD sub\_part\_cost TO assembly\_cost

END FOR

SET assembly\_specific\_cost = rates[assembly] \* (work\_centre\_params.assembly\_components + work\_centre\_params.assembly\_sequence)

IF weldment\_indicator = "Yes"

MULTIPLY assembly\_specific\_cost BY weldment\_complexity\_factor

ELSE

MULTIPLY assembly\_specific\_cost BY assembly\_complexity\_factor

ADD assembly\_specific\_cost TO assembly\_cost

MULTIPLY assembly\_cost BY batch\_quantity

MULTIPLY assembly\_cost BY batch\_discount\_factor(batch\_quantity)

ADD assembly\_cost TO total\_cost

END IF

WRITE part\_number, revision\_level, weldment\_indicator, top\_level\_assembly, sub\_parts, batch\_quantity, total\_cost TO data/output.txt

RETURN total\_cost

END FUNCTION

FUNCTION calculate\_single\_part\_cost(part, params, rates)

SET part\_cost = 0

IF params.cutting\_method IS NOT "None"

SET work\_cost = rates[params.cutting\_method] \* params.cutting\_complexity

ADD work\_cost TO part\_cost

IF params.bends > 0

SET work\_cost = rates[bending] \* params.bends

ADD work\_cost TO part\_cost

IF params.weld\_length > 0

SET work\_cost = rates[params.weld\_type] \* params.weld\_length

IF params.weld\_quality = "High"

MULTIPLY work\_cost BY weld\_quality\_factor

ADD work\_cost TO part\_cost

IF params.deburring\_intensity IS NOT "None"

SET work\_cost = rates[params.deburring\_intensity] \* (part.length \* part.width)

ADD work\_cost TO part\_cost

IF params.inspection\_scope IS NOT "None"

SET work\_cost = rates[params.inspection\_scope] \* params.inspection\_points

ADD work\_cost TO part\_cost

IF params.surface\_treatment\_type IS NOT "None"

SET work\_cost = rates[params.surface\_treatment\_type] \* (part.length \* part.width)

IF params.surface\_treatment\_coverage = "Full"

MULTIPLY work\_cost BY treatment\_factor

ADD work\_cost TO part\_cost

IF params.machining\_operations > 0

SET work\_cost = rates[params.machining\_precision] \* params.machining\_operations

ADD work\_cost TO part\_cost

IF params.forming\_steps > 0

SET work\_cost = rates[params.forming\_complexity] \* params.forming\_steps

ADD work\_cost TO part\_cost

IF params.fastener\_types\_and\_counts IS NOT EMPTY

SET fastening\_cost = 0

FOR EACH fastener IN params.fastener\_types\_and\_counts

ADD (rates[fastener.type] \* fastener.count) TO fastening\_cost

END FOR

ADD fastening\_cost TO part\_cost

RETURN part\_cost

END FUNCTION