

# Sheet Metal Client Hub Design Document

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*Prepared by: Laurie Moffat*

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## 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:

<i>Field</i>	<i>Type</i>	<i>Description</i>	<i>Constraints</i>
<b>part_type</b>	String	Indicates if the input is a single part or an assembly	Mandatory, must be "Single Part" or "Assembly"
<b>part_number</b>	String	Unique identifier for the part or assembly	Mandatory, format PART- [5-15 alphanumeric characters], no spaces
<b>revision_level</b>	String	Engineering design revision level	Mandatory, format Rev [A-Z0-9]{1-5}, max 9 characters including "Rev "
<b>weldment_indicator</b>	String	Indicates if the assembly is a weldment	Mandatory for part_type = "Assembly", must be "Yes" or "No", disabled for Single Part

<b><i>top_level_assembly</i></b>	String	Identifier for the parent assembly	Mandatory for part_type = "Assembly", format ASSY-[5-15 alphanumeric], no spaces
<b><i>sub_parts</i></b>	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
<b><i>material</i></b>	String	Material type	Selected from predefined list
<b><i>thickness</i></b>	Float	Material thickness in mm	Must be one of 1, 1.2, 1.5, 2, 2.5, 3
<b><i>length</i></b>	Float	Lay-flat length in mm	50 <= length <= 3000
<b><i>width</i></b>	Float	Lay-flat width in mm	50 <= width <= 1500
<b><i>bends</i></b>	Integer	Number of bends in the part	0 <= bends <= 20
<b><i>cutting_method</i></b>	String	Cutting process for the part	Mandatory, must be "Laser Cutting", "Turret Press Punching", or "None"
<b><i>cutting_complexity</i></b>	Integer	Number of cuts or contour complexity	1 <= cutting_complexity <= 10 if cutting_method is not None, otherwise 0
<b><i>weld_length</i></b>	Float	Weld length in mm	0 <= weld_length <= 5000, default 0
<b><i>weld_type</i></b>	String	Type of welding process	None, MIG, TIG; mandatory if weld_length > 0, otherwise None
<b><i>weld_quality</i></b>	String	Quality level of welding	Standard, High; mandatory if weld_length > 0, otherwise None
<b><i>deburring_intensity</i></b>	String	Intensity of deburring required	Mandatory, must be "None", "Light", or "Heavy"
<b><i>assembly_components</i></b>	Integer	Number of components for assembly integration	0 <= assembly_components <= 50, default 0
<b><i>assembly_sequence</i></b>	Integer	Position in the assembly sequence	0 <= assembly_sequence <= 10, default 0
<b><i>inspection_scope</i></b>	String	Scope of inspection required	Mandatory, must be "None", "Standard", or "Comprehensive"
<b><i>inspection_points</i></b>	Integer	Number of points or features inspected	0 <= inspection_points <= 50, default 0
<b><i>surface_treatment_type</i></b>	String	Type of surface treatment	Mandatory, must be "None", "Painting", or "Coating"

<b><i>surface_treatment_coverage</i></b>	String	Coverage area for surface treatment	None, Partial, Full; mandatory if surface_treatment_type is not None
<b><i>machining_operations</i></b>	Integer	Number of machining operations	0 <= machining_operations <= 20, default 0
<b><i>machining_precision</i></b>	String	Precision level for machining	None, Standard, High; mandatory if machining_operations > 0, otherwise None
<b><i>forming_steps</i></b>	Integer	Number of forming steps	0 <= forming_steps <= 10, default 0
<b><i>forming_complexity</i></b>	String	Complexity of forming	None, Low, Medium, High; mandatory if forming_steps > 0, otherwise None
<b><i>fastener_types_and_counts</i></b>	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
<b><i>batch_quantity</i></b>	Integer	Number of identical parts or assemblies in a batch	Mandatory, 1 <= batch_quantity <= 1000
<b><i>customer_name</i></b>	String	Name of the customer	Mandatory for quote generation, max 100 characters
<b><i>customer_contact</i></b>	String	Customer contact details	Optional, max 100 characters
<b><i>project_reference</i></b>	String	Customer project identifier	Optional, max 50 characters
<b><i>quote_number</i></b>	String	Unique identifier for the quote	Mandatory, format QUOTE-[YYYY]-[0-9]{3}, auto-generated
<b><i>quote_date</i></b>	Date	Date the quote is generated	Mandatory, auto-set to current date (e.g., 6 May 2025)
<b><i>validity_period</i></b>	Integer	Number of days the quote is valid	Optional, 1 <= validity_period <= 90, default 30
<b><i>quote_terms</i></b>	String	Terms or conditions for the quote	Optional, max 500 characters
<b><i>profit_margin</i></b>	Float	Percentage markup on costs	Mandatory, 0 <= profit_margin <= 100
<b><i>overhead_rate</i></b>	Float	Percentage for indirect costs	Optional, 0 <= overhead_rate <= 50, default 0

<b><i>discount</i></b>	Float	Percentage discount on total cost	Optional, 0 <= discount <= 50, default 0
<b><i>delivery_timeframe</i></b>	String	Estimated delivery timeframe	Optional, max 50 characters
<b><i>delivery_location</i></b>	String	Customer delivery location	Optional, max 100 characters

## Diagrams

- 1) **Gantt Chart (docs/diagrams/Gantt Chart.png):**  
Illustrates the project timeline (1 April – 2 June 2025).
- 2) **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.
- 3) **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.
- 4) **Structure Chart (docs/diagrams/Structure\_Chart.png):**  
Depicts modular organization (main.py, gui.py, calculator.py, file\_handler.py, tests).
- 5) **Class Diagram (docs/diagrams/Class\_Diagram.png):**  
Defines classes (App, Calculator, FileHandler) with updated attributes for revision levels and quoting.
- 6) **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.
- 7) **Entity-Relationship Diagram (ERD) (docs/diagrams/ERD.png):**  
Models User, Part, and Rate relationships, including sub-parts, revision levels, and welding parameters for weldments.
- 8) **State Diagram (docs/diagrams/State\_Diagram.png):**  
Shows GUI state transitions (Login, Part Input [Single Part/Assembly/Weldment], Quote Generation, Output).
- 9) **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.
- 10) **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

```