Sheet Metal Client Hub Design Document

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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:

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

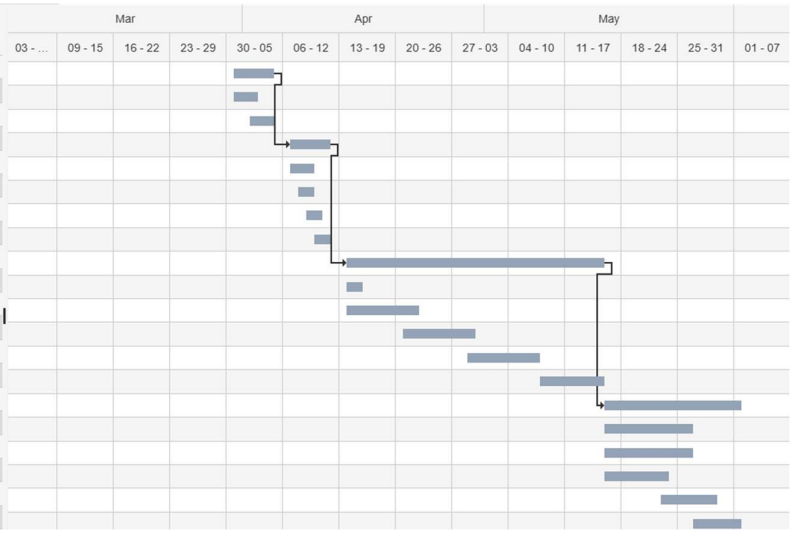
thickness	Float	Material thickness in mm	Must be one of 1, 1.2, 1.5, 2, 2.5, 3
length	Float	Lay-flat length in mm	50 <= length <= 3000
width	Float	Lay-flat width in mm	50 <= width <= 1500
bends	Integer	Number of bends in the part	0 <= bends <= 20
cutting_method	String	Cutting process for the part	Mandatory, 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

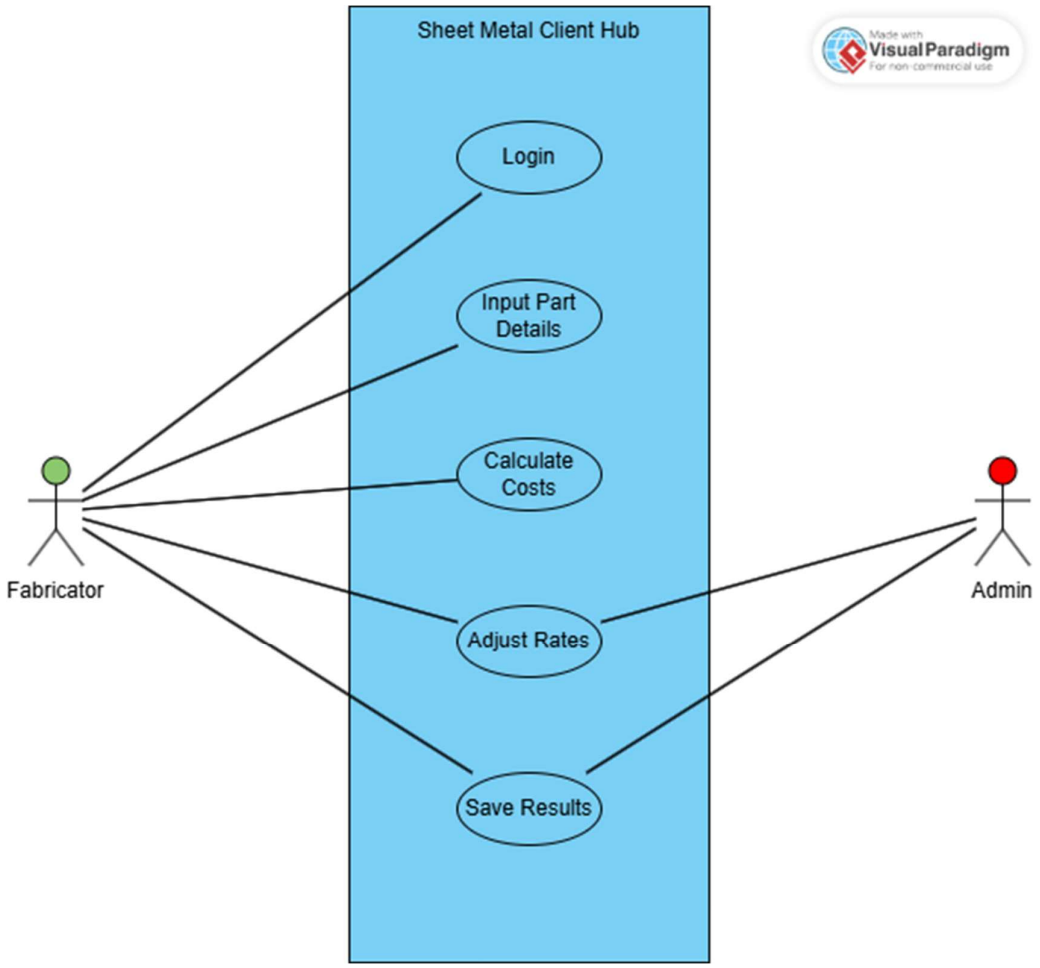
Diagrams

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

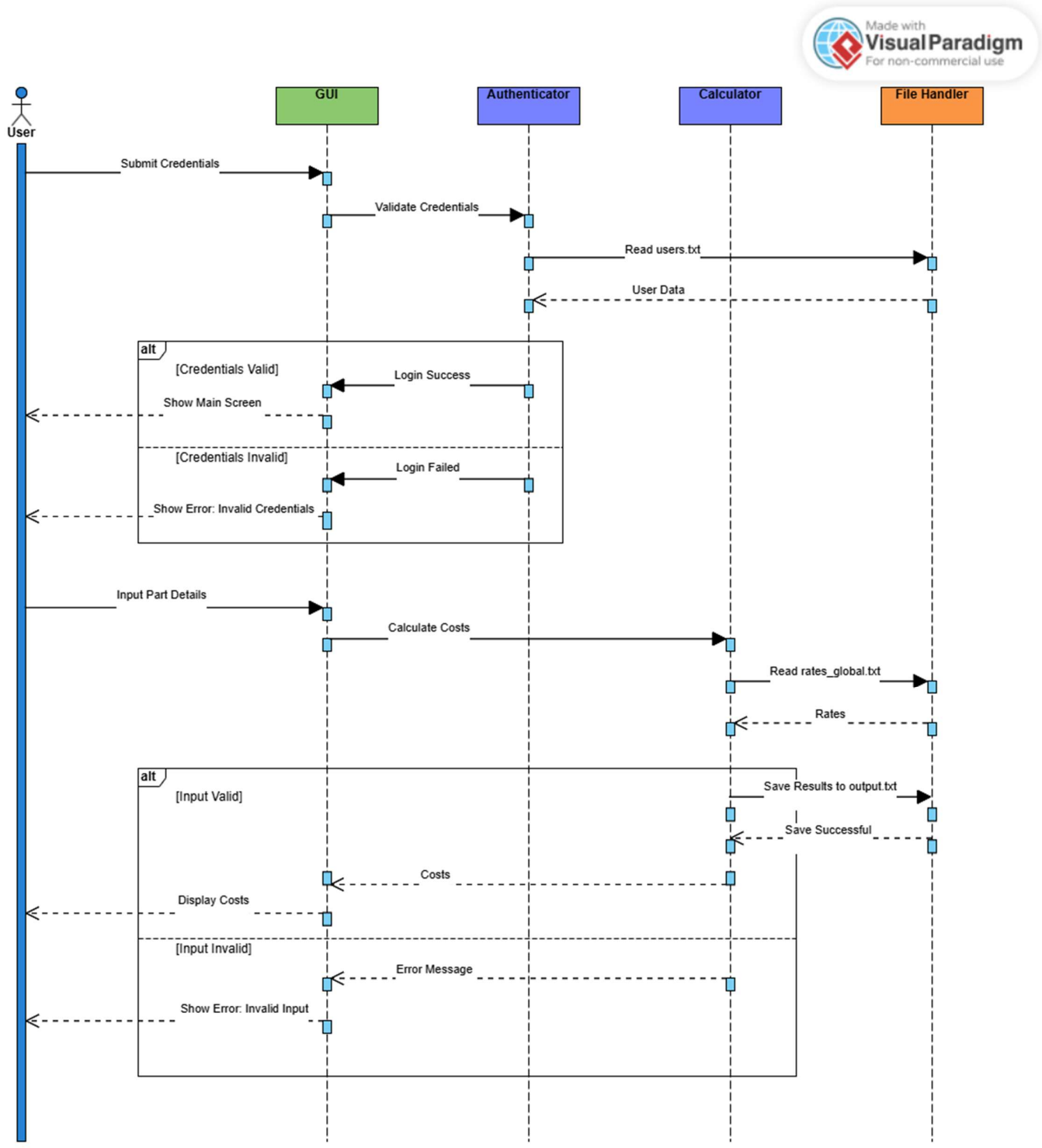
ID	Title	Start Time	End Time
1	**Planning**	03/31/2025	04/05/2025
2	Define scope	03/31/2025	04/03/2025
3	Create development plan	04/02/2025	04/05/2025
4	**Design**	04/07/2025	04/12/2025
5	Wireframes	04/07/2025	04/10/2025
6	Data dictionary	04/08/2025	04/10/2025
8	Pseudocode	04/09/2025	04/11/2025
7	Structure chart	04/10/2025	04/12/2025
9	**Development**	04/14/2025	05/16/2025
10	Setup environment	04/14/2025	04/16/2025
11	Login module	04/14/2025	04/23/2025
12	Input module	04/21/2025	04/30/2025
13	Output module	04/29/2025	05/08/2025
14	Settings module	05/08/2025	05/16/2025
15	**Testing & Docs**	05/16/2025	06/02/2025
16	Unit testing	05/16/2025	05/27/2025
17	Integration testing	05/16/2025	05/27/2025
18	System testing	05/16/2025	05/24/2025
19	Debug and fix	05/23/2025	05/30/2025
20	Final documentation	05/27/2025	06/02/2025



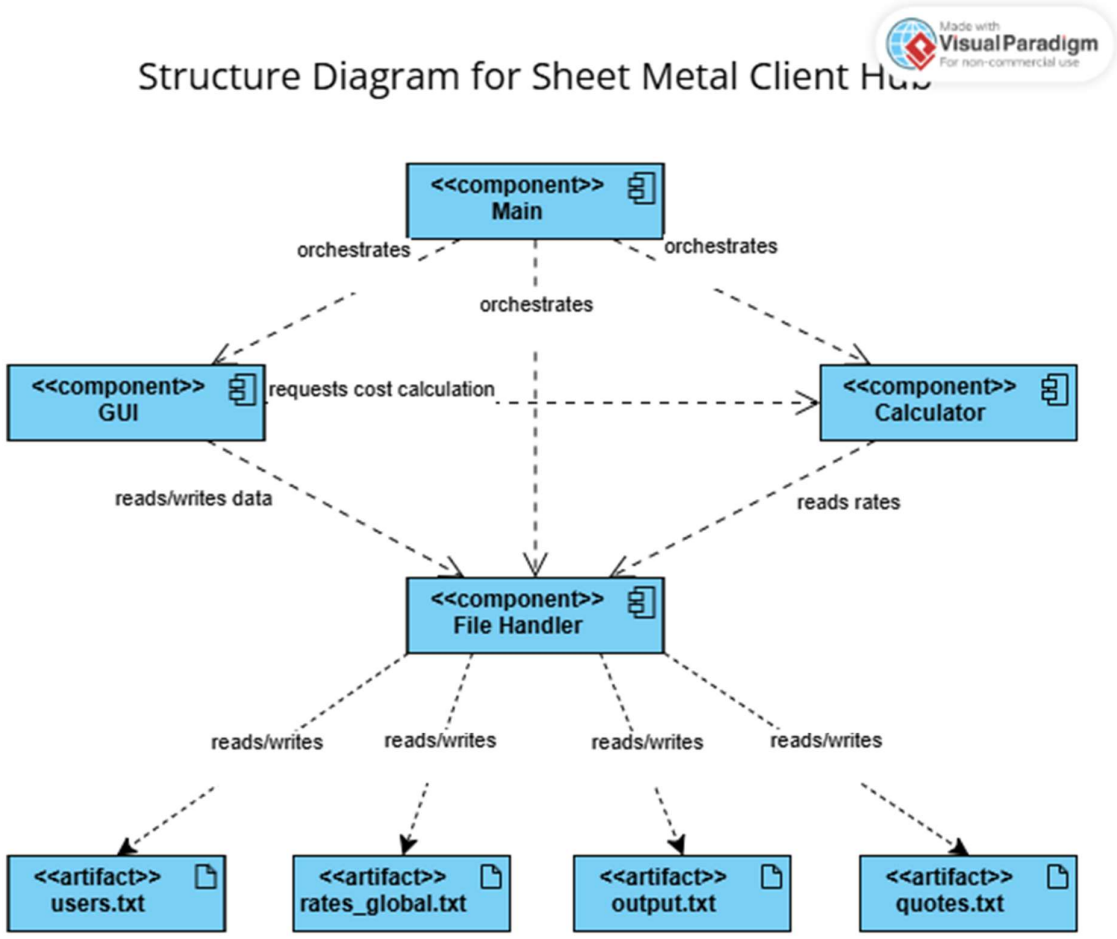
2) Use Case Diagram (docs/diagrams/Use_Case_Diagram.png):



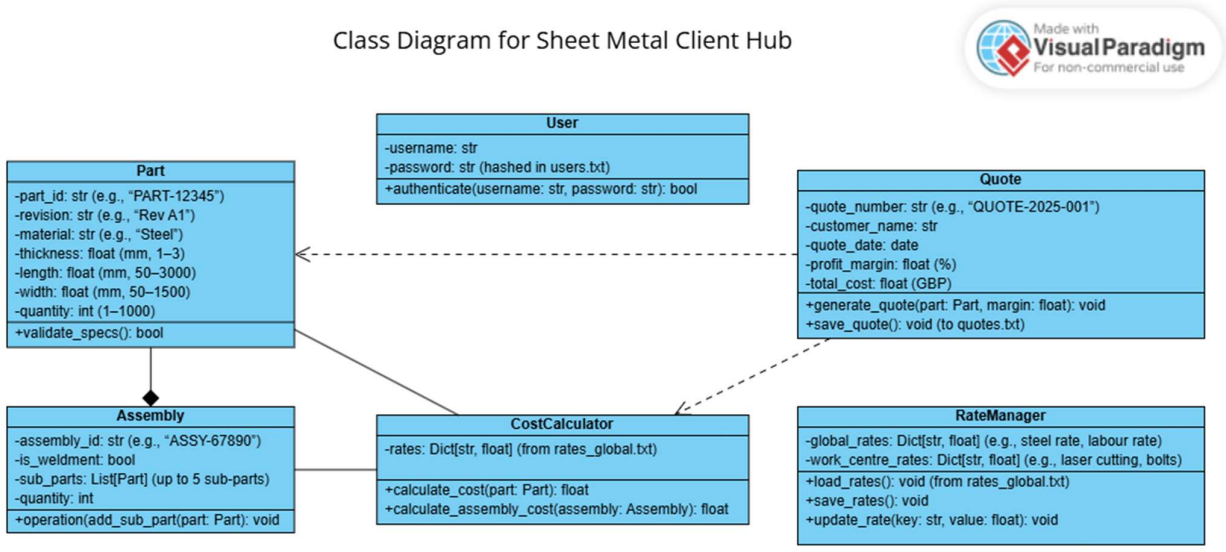
3) Sequence Diagram (docs/diagrams/Sequence_Diagram.png):



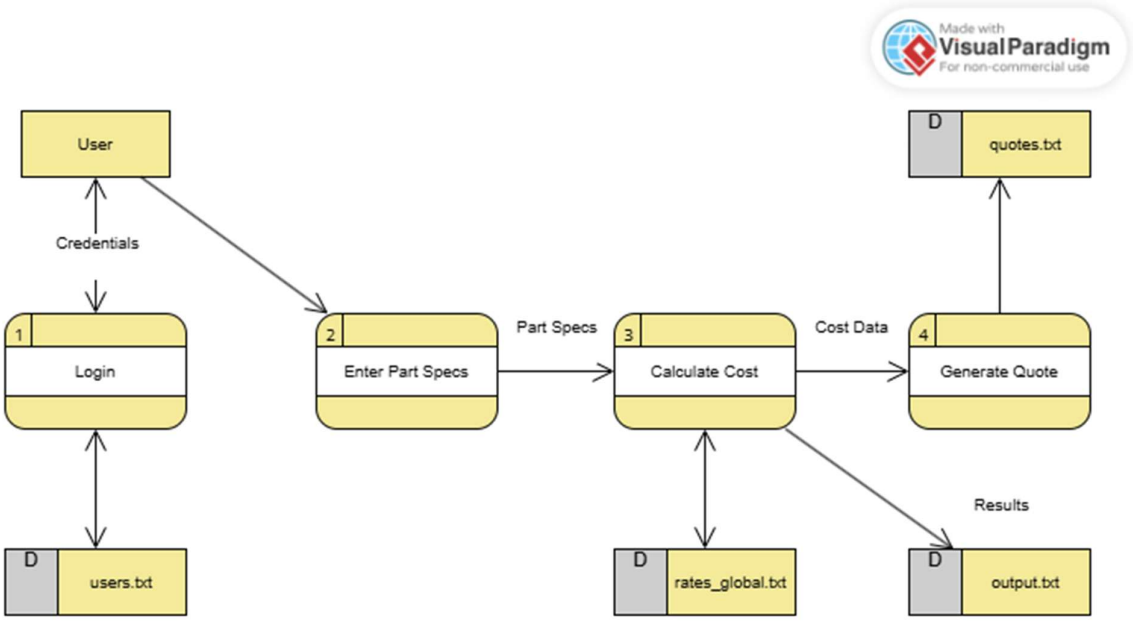
4) Structure Chart (docs/diagrams/Structure_Chart.png):



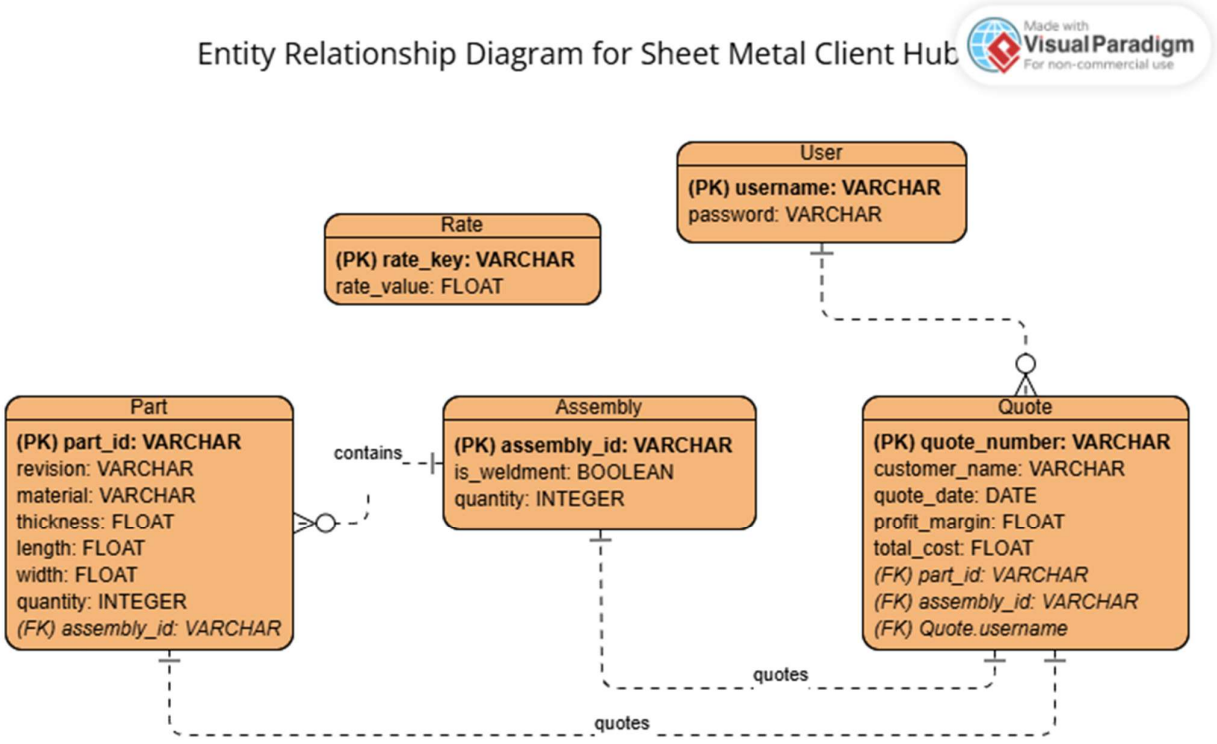
5) Class Diagram (docs/diagrams/Class_Diagram.png):



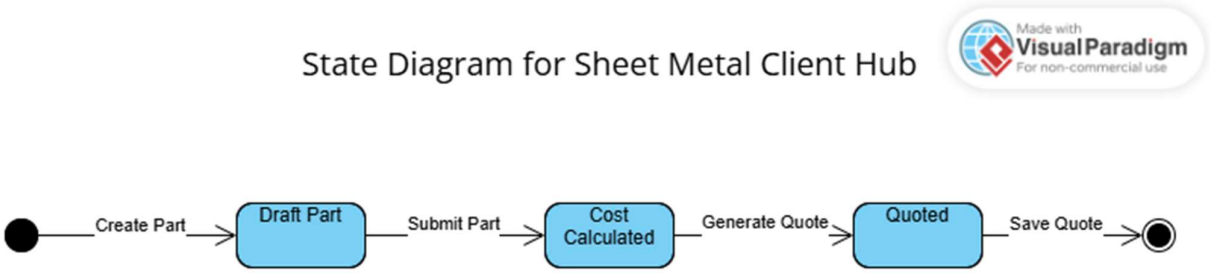
6) Data Flow Diagram (DFD) (docs/diagrams/DFD.png):



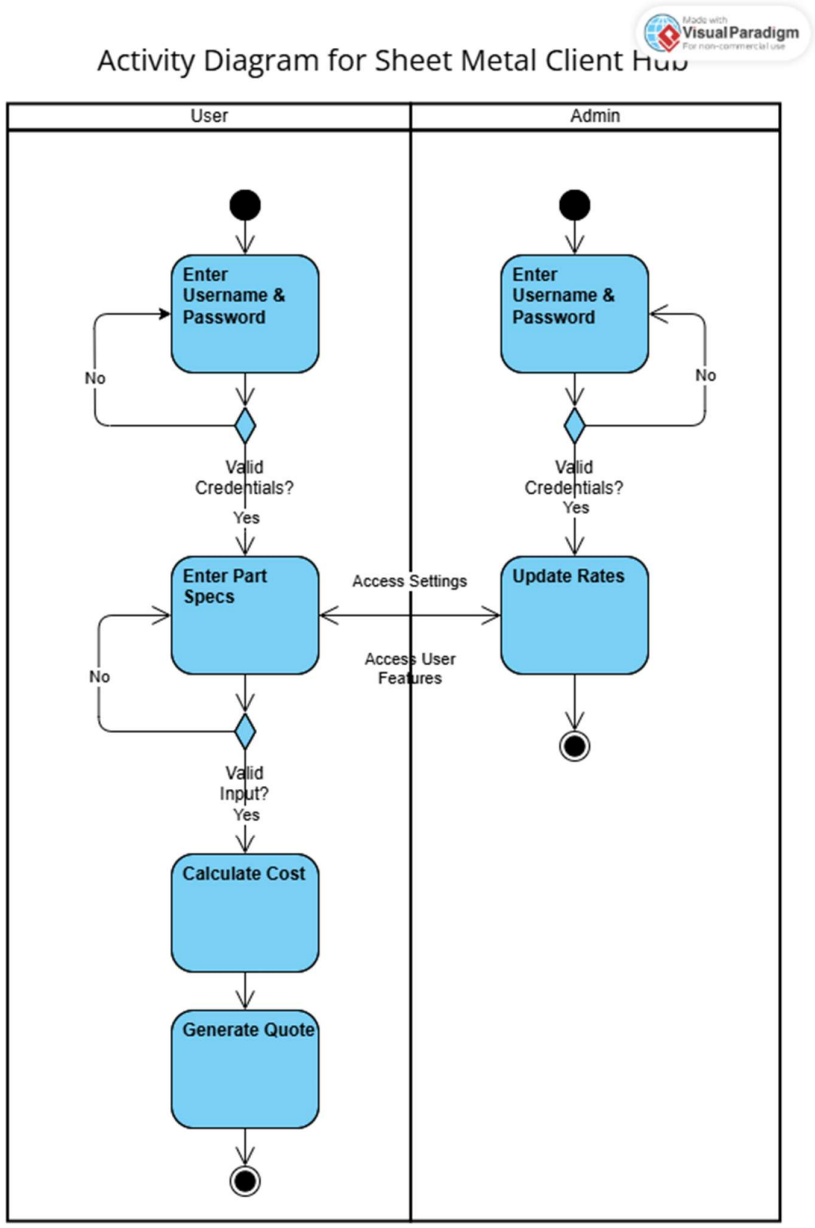
7) Entity-Relationship Diagram (ERD) (docs/diagrams/ERD.png):



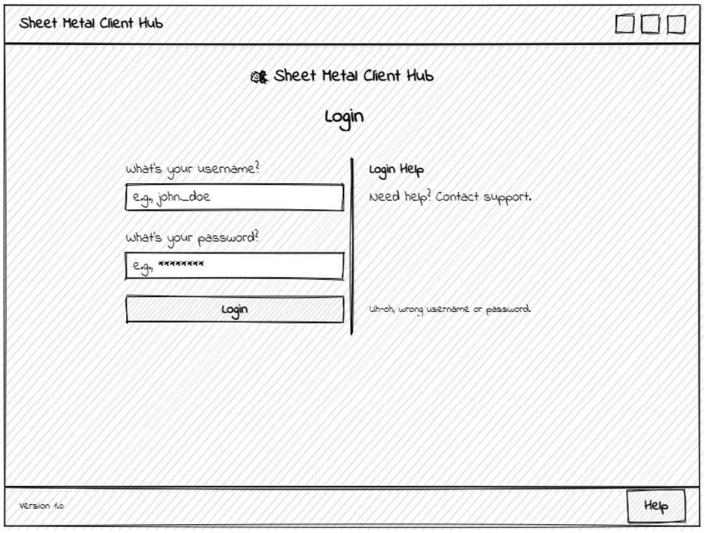
8) State Diagram (docs/diagrams/State_Diagram.png):

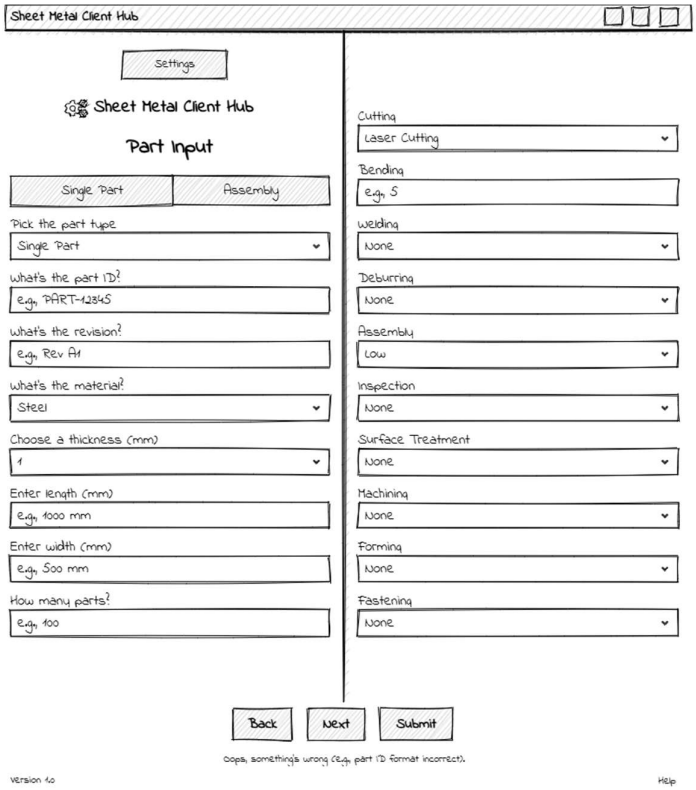


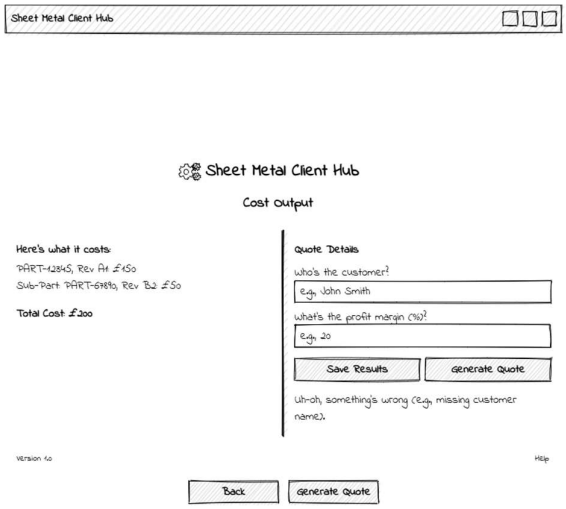
9) Activity Diagram (docs/diagrams/Activity_Diagram.png):

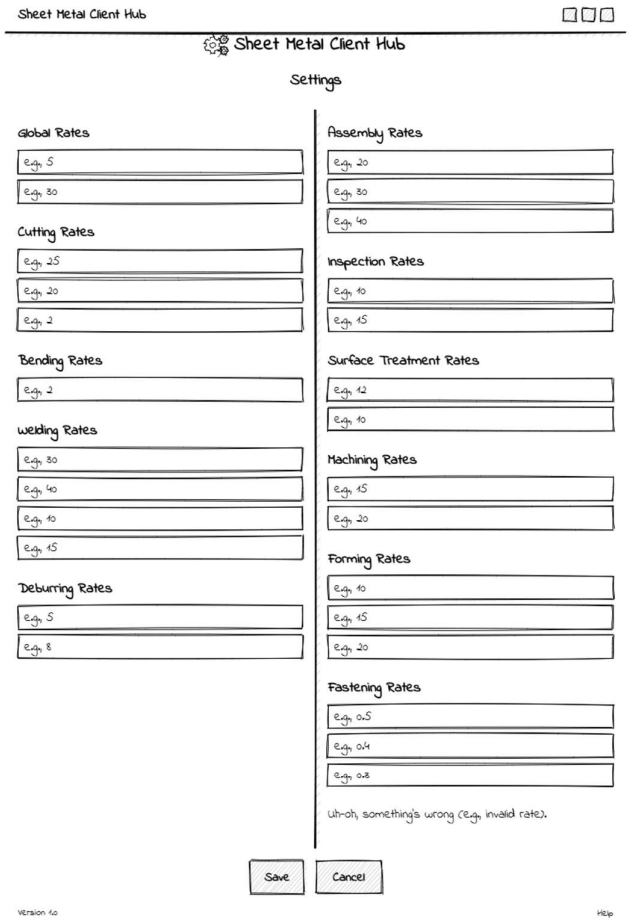


10) Wireframes (docs/diagrams/wireframes):






Sheet Metal Client Hub
Sheet Metal Client Hub
Cost Output
Here's what it costs:
PART-12345, Rev A1 £150
Sub-Part PART-67890, Rev B2 £50
Total Cost: £200
Quote Details
Who's the customer?
e.g. John Smith
What's the profit margin (%)?
e.g. 20
Save Results
Generate Quote
Uh-oh, something's wrong (e.g. missing customer name).
Version 1.0
Help
Back
Generate Quote


Sheet Metal Client Hub
Sheet Metal Client Hub
Settings
Global Rates
e.g. 5
e.g. 30
Cutting Rates
e.g. 25
e.g. 20
e.g. 2
Bending Rates
e.g. 2
Welding Rates
e.g. 30
e.g. 40
e.g. 10
e.g. 15
Deburring Rates
e.g. 5
e.g. 8
Assembly Rates
e.g. 20
e.g. 30
e.g. 40
Inspection Rates
e.g. 10
e.g. 15
Surface Treatment Rates
e.g. 12
e.g. 10
Machining Rates
e.g. 15
e.g. 20
Forming Rates
e.g. 10
e.g. 15
e.g. 20
Fastening Rates
e.g. 0.5
e.g. 0.4
e.g. 0.8
Uh-oh, something's wrong (e.g. invalid rate).
Save
Cancel
Version 1.0
Help

Pseudocode

```
# FR1: Login (User and Admin)
FUNCTION Login
  WHILE NOT ValidCredentials(username, password) DO
    INPUT username, password
    IF ValidateCredentials(username, password) THEN
      Display "Login successful"
      IF IsAdmin(username) THEN
        RETURN "Admin"
      ELSE
        RETURN "User"
      ENDIF
    ELSE
      Display "Invalid credentials, please try again"
    ENDIF
  ENDWHILE
END

# FR2: Part Input (User)
FUNCTION EnterPartSpecs
  WHILE NOT ValidPartSpecs(thickness, length, width, quantity) DO
    INPUT part_id, revision, material, thickness, length, width, quantity
    IF ValidatePartSpecs(thickness, length, width, quantity) THEN
      SavePartSpecs(part_id, revision, material, thickness, length, width, quantity)
      RETURN TRUE
    ELSE
      Display "Invalid part specifications, please try again"
    ENDIF
  ENDWHILE
END

# FR3-FR4: Cost Calculation (User)
FUNCTION CalculateCost(part_id, revision, material, thickness, length, width, quantity)
  LOAD rates FROM rates_global.txt
  SET material_rate = GetRate(material, rates)
  SET labour_rate = GetRate("labour_rate", rates)
  SET process_rates = GetProcessRates(rates) # e.g., laser_cutting, bending
  SET total_cost = 0
  SET volume = thickness * length * width
  SET material_cost = volume * material_rate * quantity
  SET labour_cost = volume * labour_rate * quantity
  SET process_cost = CalculateProcessCost(process_rates, quantity)
  SET total_cost = material_cost + labour_cost + process_cost
  RETURN total_cost
END

# FR5: Store Output (User)
FUNCTION StoreOutput(part_id, revision, material, thickness, length, width, quantity, total_cost)
  SET timestamp = GetCurrentDate()
```

```
    WRITE TO output.txt: part_id, revision, material, thickness, length, width, quantity, total_cost, timestamp
    Display "Cost calculation saved successfully"
END
```

 # FR7: Generate Quote (User)

```
FUNCTION GenerateQuote(part_id, total_cost, customer_name, profit_margin)
    SET quote_number = GenerateUniqueQuoteNumber()
    SET quote_total = total_cost * (1 + profit_margin / 100)
    SET timestamp = GetCurrentDate()
    WRITE TO quotes.txt: quote_number, customer_name, quote_total, profit_margin, timestamp, part_id
    Display "Quote generated successfully"
END
```

 # FR6: Update Rates (Admin)

```
FUNCTION UpdateRates
    INPUT rate_key, rate_value
    LOAD rates FROM rates_global.txt
    SET rates[rate_key] = rate_value
    SAVE rates TO rates_global.txt
    Display "Rates updated successfully"
END
```

 # Main Program

```
FUNCTION Main
    SET role = Login()
    IF role = "User" THEN
        EnterPartSpecs()
        SET total_cost = CalculateCost(part_id, revision, material, thickness, length, width, quantity)
        StoreOutput(part_id, revision, material, thickness, length, width, quantity, total_cost)
        INPUT customer_name, profit_margin
        GenerateQuote(part_id, total_cost, customer_name, profit_margin)
    ELSE IF role = "Admin" THEN
        UpdateRates()
        # Optionally access User features
        IF AdminChoosesUserFeatures THEN
            EnterPartSpecs()
            SET total_cost = CalculateCost(part_id, revision, material, thickness, length, width, quantity)
            StoreOutput(part_id, revision, material, thickness, length, width, quantity, total_cost)
            INPUT customer_name, profit_margin
            GenerateQuote(part_id, total_cost, customer_name, profit_margin)
        ENDIF
    ENDIF
END
```