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Collected data and assumptions

This section summarizes the main information collected at the beginning of the project as well as the assumptions made. All these information were used as basis for the development of the final assembly line concept.

1. The main components to be delivered at the beginning of the FAL are:
   I. Three fuselage section (F1+F2, F3, F4+F5) already equipped with doors, windows and main piping.
   II. Two half-wings already equipped with pylons, flaps and ailerons.
   III. Vertical Tail Plane (VTP)
   IV. Horizontal Tail Plane (HTP) divided in two single parts (RH and LH) to be assembled separately on both sides of the „F4+F5“ section.
   V. Two Main Landing Gears (MLG) and one Nose Landing Gear (NLG)
   VI. Two engines
   VII. Auxiliary Power Unit (APU), Elevators, Rudder

2. The location of the FAL is still not defined, but a hourly rate of 5-10€ and a 2 shifts production (2 x 8 hours) shall be considered for this analysis.
3. As the location of the FAL is still not defined, the layout planning starts with a green field.

4. No composite parts will be used in the aircraft.

5. The connection Wing/Fuselage will be done as usually done for other commercial aircrafts.

6. The connection HTP/Fuselage will follow the same principles as the connection Wing/Fuselage.

7. Small parts will be assembled hole-to-hole while large components will be aligned using auxiliary measuring systems (e.g. Laser Tracker).

8. Two production rates shall be considered, 15 AC/Year and 45 AC/Year (ramp up after 5 years).

9. The design of the Manufacturing Execution System (MES) shall be kept as simple as possible.

10. Painting is not part of the FAL.

11. Large interior parts will be loaded into the fuselage sections before the fuselage assembly.
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Frigate Ecojet – Final Assembly Line (FAL)

Basic Data

Cycle Time:
- 15 & 45 AC per year
- Rate 1.25 – 3.75 AC per month
- 246 working days per year
- Double day shifts, 8 effective hours per shift / 5 days per week

Environmental conditions (suggestion):
- Temperature range 18°C-23°C
- Relative Humidity 50-70%
- No direct sunlight

Location:
- To be defined
- Hourly Rate: 5 – 10 €
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Build Philosophy St. 10

1. Assembly of large interior parts inside sections
2. Load sections on positioners and align
3. Drill / clean / seal / fasten sections
Build Philosophy St. 20

1. Load fuselage on positioners
2. Load and align wings and HTP-Boxes to fuselage (Best fitting)
3. Drilling & riveting operation in wings and HTP-Boxes
4. VTP and APU assembly
5. Belly Fairing assembly
6. MLG & NLG assembly
7. Electric „power on“
Build Philosophy St. 30

1. Test station:
   I. Hydraulic system
   II. Actuators
   III. Fire system
   IV. Fuel system
   V. Flight and navigation facility
   VI. Anti-ice system
   VII. Water supply and disposal systems
   VIII. Service equipment
   IX. Weighing
   X. ...
## Build Philosophy St. 40

<table>
<thead>
<tr>
<th>1. Engine Assembly</th>
<th>5. Radom</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Interior Assembly</td>
<td></td>
</tr>
<tr>
<td>3. Test Engine and APU installation</td>
<td></td>
</tr>
<tr>
<td>4. Test of landing gears</td>
<td></td>
</tr>
<tr>
<td>6. Test of Multimedia System</td>
<td></td>
</tr>
<tr>
<td>7. Test of oxygen equipment</td>
<td></td>
</tr>
<tr>
<td>8. Engine Test (Outside)</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram of an airplane with labels for engine assemblies and tests.]
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Station 10:
- Assembly of large interior parts
- Fuselage Assembly

Station 20:
- HTP, VTP and APU Assembly
- Wings Assembly
- Landing gears Assembly
- Belly fairing Assembly
- Electric „Power on“

Station 30:
- Test of:
  - Hydraulic system
  - Actuators test
  - Fire system test
  - Fuel system
  - Flight and navigation sys.
  - …

Station 40:
- Engines Assembly
- Interior Assembly
- Test Engine and APU installation
- Test of oxygen system
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General workload

<table>
<thead>
<tr>
<th>Cycle Time [h]</th>
<th>St. 10 - Fuselage Assembly</th>
<th>St. 20 - Wings and Empennage Assembly</th>
<th>St. 30 - Engine and Interior Assembly</th>
<th>St. 40 - Test of equipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>72,8 h</td>
<td></td>
<td>71,6 h</td>
<td>69,8 h</td>
<td>74,1 h</td>
</tr>
</tbody>
</table>

RATE 45

Station 10 – Cycle time diagram

<table>
<thead>
<tr>
<th>Station</th>
<th>Task Description</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Measure &amp; Align Sections</td>
<td>1</td>
<td>120</td>
<td>4</td>
<td></td>
<td>2028</td>
</tr>
<tr>
<td>10</td>
<td>Positioning of Stringer joins</td>
<td>256</td>
<td>1</td>
<td>4</td>
<td></td>
<td>2148</td>
</tr>
<tr>
<td>10</td>
<td>Position drilling templates</td>
<td>48</td>
<td>4</td>
<td>4</td>
<td></td>
<td>2212</td>
</tr>
<tr>
<td>10</td>
<td>Drill connection F1/F2</td>
<td>6123</td>
<td>0.17</td>
<td>2</td>
<td></td>
<td>2260</td>
</tr>
</tbody>
</table>

Please refer to the delivered cycle time diagram
Station 10 - Ramp-up & Leaning curve

Rate/Component

Rate 15
Rate 45

Quantity produced

Rate 15
Rate 45
Station 20 - Cycle time diagram

<table>
<thead>
<tr>
<th>Station</th>
<th>Activity Description</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Load HTP-Boxes onto positioners</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>20</td>
<td>Measure wings, fuselage and HTP-Boxes</td>
<td>1</td>
<td>180</td>
</tr>
<tr>
<td>20</td>
<td>Move wings and HTP-Boxes to best fit position</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>20</td>
<td>Shim (measure, prepare, install) for left wing</td>
<td>1</td>
<td>360</td>
</tr>
</tbody>
</table>

Please refer to the delivered cycle time diagram
Station 20 - Ramp-up & Leaning curve

![Graph showing ramp-up and leaning curve with rates 15 and 45]
Station 30 - Cycle time diagram

Please refer to the delivered cycle time diagram
Station 30 - Ramp-up & Leaning curve

Rate/Component

Month

Components per Month

Rate (required) vs. Rate (possible)

RATE 15

RATE 45

Quantity produced

Month

Quantity (total)

Rate (required) vs. Rate (possible)

30.09.2013

Frigate Ecojet -- Final Assembly Line (FAL)

ThyssenKrupp System Engineering
Assembly Systems - Aerospace
Station 40 - Cycle time diagram

Please refer to the delivered cycle time diagram
Station 40 - Ramp-up & Leaning curve

Rate/Component

Month

Components per Month

Rate (required)
Rate (possible)

RATE 15
RATE 45

Quantity produced

Month

Quantity (total)

Quantity (required)
Quantity (possible)
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Layout – Plant Overview

Plant dimensions: 380 m x 560 m

Please refer to the delivered Layout as PDF

Layout considering dedicated areas for:
- Final Assembly Line
- Logistic center
- Delivery center
- Customer acceptance
- Office and Service
Layout - FAL Assembly Overview

Assembly area: 254 m x 80 m x 30 m
Layout - FAL Assembly 2D-View

Assembly area: 254 m x 80 m x 30 m
Layout – Station 10

- Main Platform
- Logistic Lift
- Storage area for sections
- Interior Assembly Area with static supports for sections
- Sections Junction Area with positioning system
- Laser tracker (not visible in this picture)
- Parking position for trolley (transport between St.10/St.20)
Layout – Station 20

- Logistic Lift
- HTP Positioning System
- Platform on rails
- Wing Positioning System
- Control center
- Milling center for wing- and HTP-shim
- Fixed Platform
- Movements for Load/Unload
- Storage for wings
- Storage for Empennage
- Storage for LG, Belly Fairings and other small components
- Fuselage positioning system (not visible in this picture)
- Platform on rail
- Laser tracker
Layout – Station 30

Storage Area

Movable Platforms to access the aircraft

Test control substations
Layout – Station 40

- Tripod to lift and sustain the aircraft
- Storage for Seats, Side wall panels, overhead panels, carpet and other interior parts.
- Platform on rail
- Platform on rail with conveyor to transport components
- Movable platform for Radom installation
- Fixed Platform
- Storage for auxiliary equipment
- Movements for Load/Unload
- Trolley for Engine Assembly

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Logistic Concept

Please refer to the delivered logistic presentation.
Please refer to the delivered media supply presentation
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Please refer to the delivered metrology presentation.
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Manufacturing Execution System (MES)

Please refer to the delivered MES presentation

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Please refer to the delivered quality assurance presentation

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Bill of Materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Rate</th>
<th>Rate</th>
<th>Description</th>
<th>Operation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Main Platform</td>
<td>1</td>
<td>1</td>
<td>Fixed main platform around “Interior Assembly Area” and “Sections Junction Area”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Logito Lift</td>
<td>1</td>
<td>2</td>
<td>Scissor lift to bring components and tools onto the main platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Positioning system for fuselage assembly</td>
<td>1</td>
<td>1</td>
<td>Consisting of 12 single positioning towers controlled by a single central station</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>