Robotic Operations Performance Case Study

An analysis of Assembly, Painting, Welding, and Inspection tasks using BigQuery + SQL. Focus areas include:

Task efficiency (processing time)
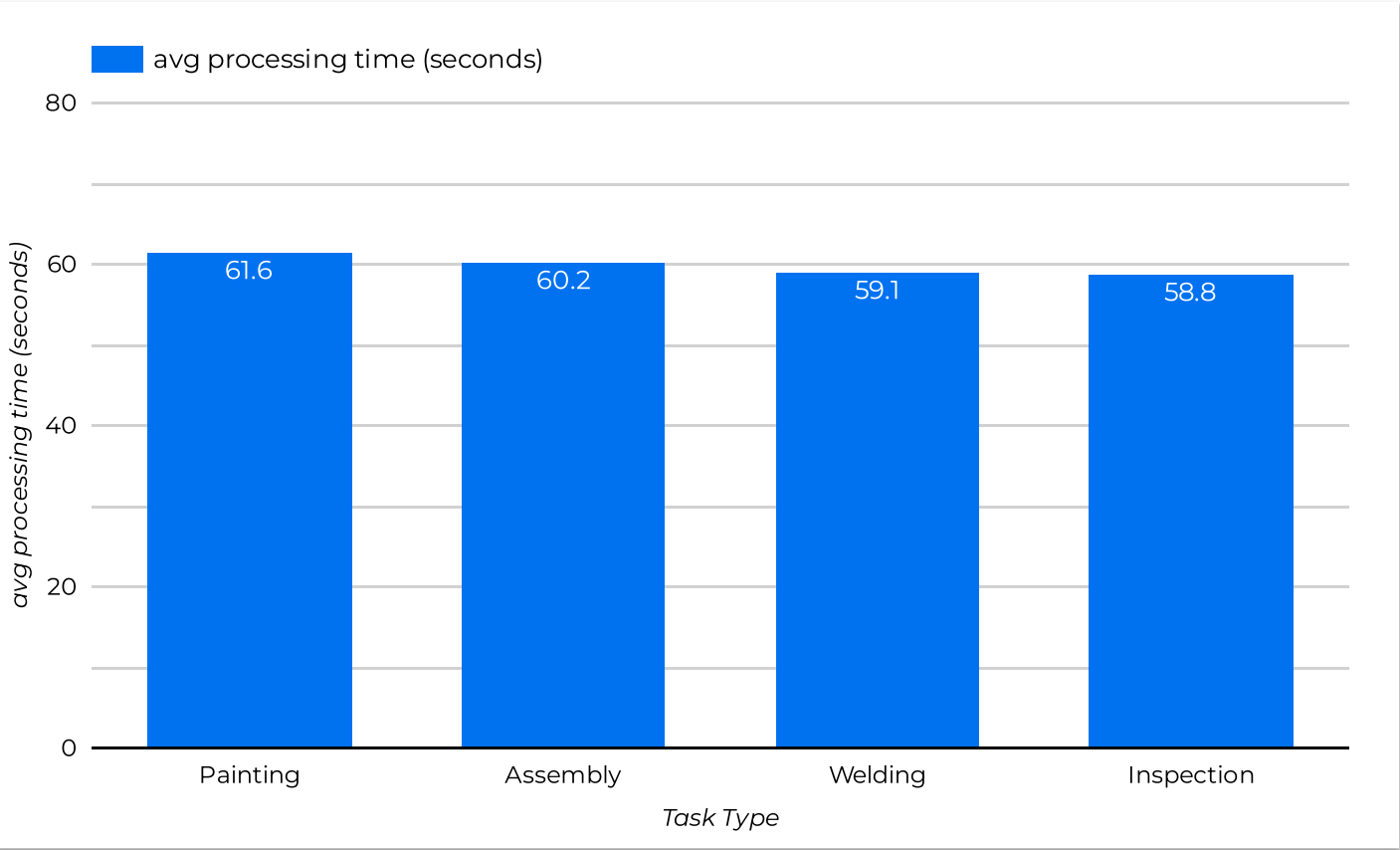
Failure and intervention trends

Impact of environmental conditions

🎯 Goal: Identify performance gaps and recommend data-driven improvements to robotic operations.

Painting and **Assembly** have the **longest average processing times,** though the margin is not significantly higher than the others.

These tasks are **potential focus areas for performance tuning**
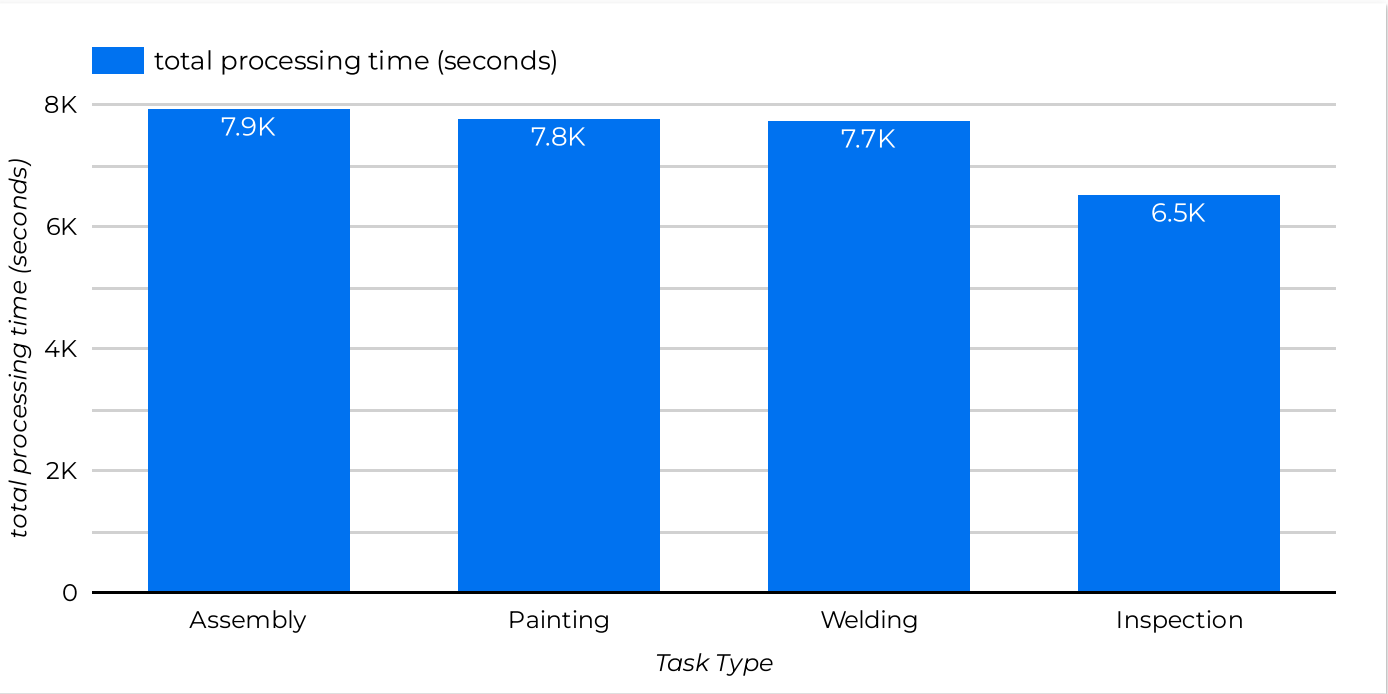
Average Processing Time by Task Type (Seconds)

Legend: avg processing time (seconds)

Y-axis: avg processing time (seconds)

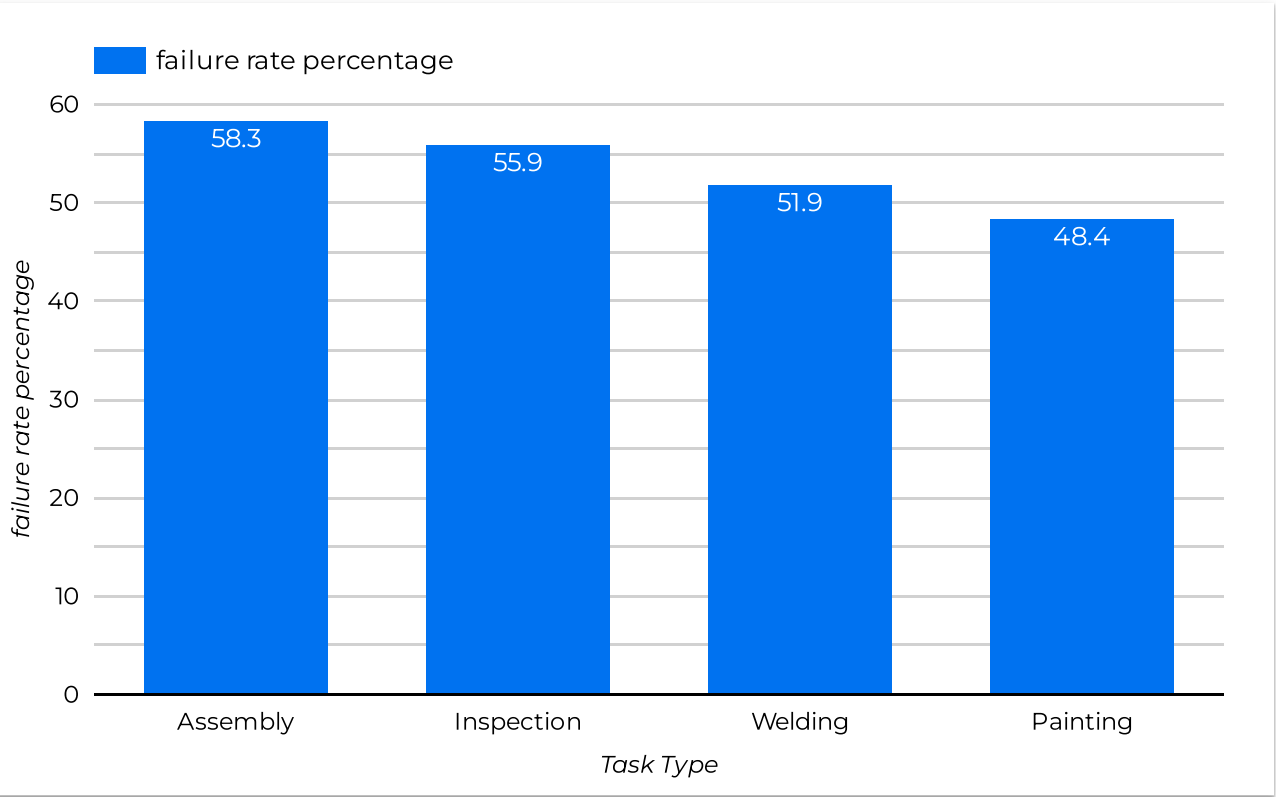| Task Type	Value
Painting	61.6
Assembly	60.2
Welding	59.1
Inspection	58.8

X-axis: Task Type

Assembly contributes the **most total processing time overall**, making it the **most time-consuming task across the operation**.

This highlights it as a strong candidate for optimization efforts.

Total Processing Time by Task Type (s)

Legend: total processing time (seconds)

Y-axis: total processing time (seconds)

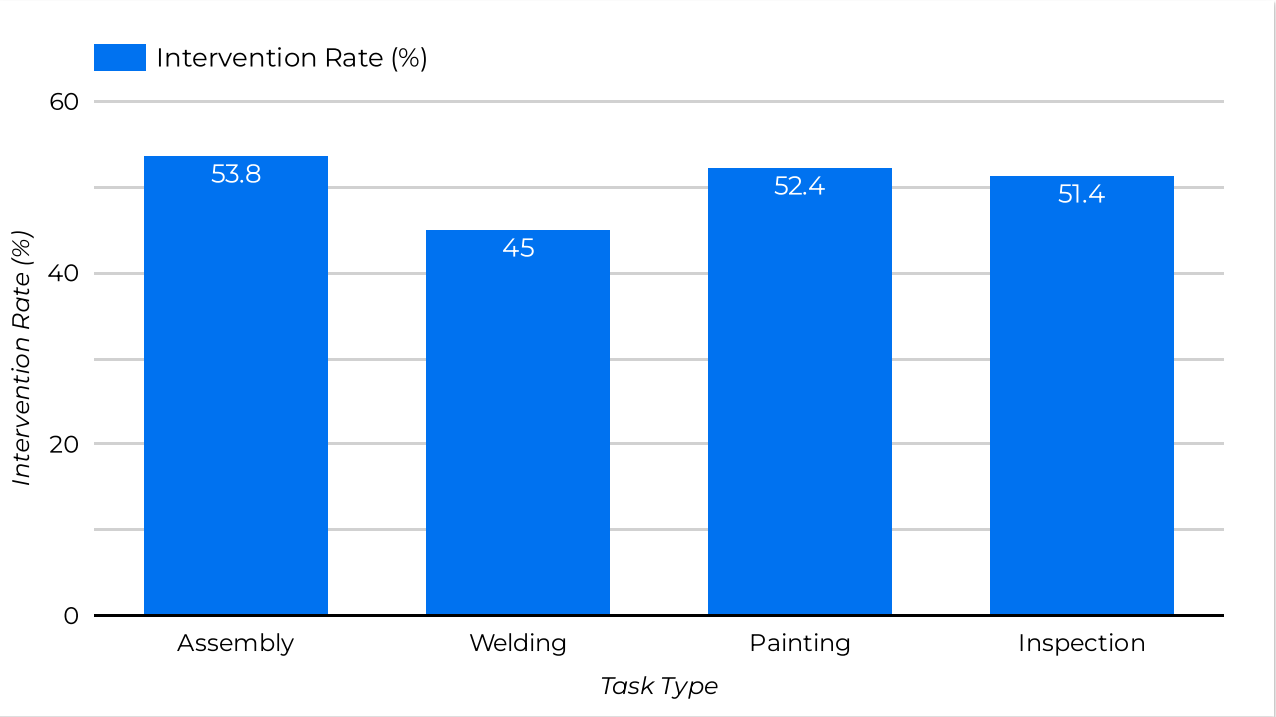| Task Type	Value
Assembly	7.9K
Painting	7.8K
Welding	7.7K
Inspection	6.5K

X-axis: Task Type

Failure Rate by Task Type (%)

Assembly has the highest failure rate, followed closely by **Inspection** and Welding.

Although the differences between tasks are not extreme, **Assembly stands out consistently as a reliability concern**.

Legend: ■ failure rate percentage

Task Type	failure rate percentage
Assembly	58.3
Inspection	55.9
Welding	51.9
Painting	48.4

Human Intervention Rate by Task Type (%)

Assembly and **Painting** show the **highest human intervention rates,** suggesting potential areas for automation refinement or task redesign to reduce manual dependencies.

Legend: ■ Intervention Rate (%)

Task Type	Intervention Rate (%)
Assembly	53.8
Welding	45
Painting	52.4
Inspection	51.4

Under unstable conditions, **Assembly** shows a **high failure rate (63.77%)** but maintains moderate processing time and intervention rates — **suggesting technical sensitivity over procedural inefficiency.**

Inspection behaves unpredictably, with its highest failure rate occurring under stable conditions. Interestingly,

Painting requires **significantly more human support in stable environments**, hinting at possible **overreliance on manual processes under normal conditions.**

Task Performance by Environmental Condition

	Task Type	Environmental_ Status	avg processing time (seconds) ▾	failure rate percentage	Intervention Rate (%)
1.	Painting	Unstable	61.79	45.9	45.9
2.	Assembly	Stable	61.4	52.38	55.6
3.	Painting	Stable	61.36	50.77	58.5
4.	Welding	Stable	60.16	52.24	41.8
5.	Assembly	Unstable	59.08	63.77	52.2
6.	Inspection	Stable	59.07	64.81	53.7
7.	Inspection	Unstable	58.53	47.37	49.1
8.	Welding	Unstable	57.95	51.56	48.4

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Strategic recommendations

Task Efficiency

Focus optimization on Assembly and Painting, which have the longest average processing times. Assembly also contributes the most total processing time, making it a high-impact target for time-reduction strategies such as robotic calibration, process redesign, or work reallocation.

Task Reliability

Assembly shows the highest failure rate and human intervention need, signaling reliability challenges. Investigate root causes such as machine-specific issues or task design complexity. Painting's high intervention rate also suggests potential for increased automation or improved standardization.

Environmental Sensitivity

Assembly's failure rate spikes under unstable conditions, while its time and intervention needs remain steady — this suggests a need for more environment-resilient automation or scheduling adjustments. Inspection shows anomalous failure under stable conditions, warranting deeper process audits. Painting performs better under unstable conditions but may be over-reliant on manual work during normal operation.

These recommendations aim to improve overall efficiency and reliability of robotic operations by targeting the highest-impact areas based on performance data.