Smurfit Westrock
FFG 3122 Flexo Folder Gluer

Performance & Downtime Analysis

Senior Design Capstone l El Paso, TX l Spring 2026

Ivan Garcia l Viridiana Martinez l Andrea Ortiz l Bryan Trevizo

Smurfit WestRock Background (El Paso)

- Leading global provider of paper-based packaging solutions
- Formed through the merger of Smurfit Kappa and WestRock
- Operates in over 40 countries worldwide
- Focus on sustainable and recyclable packaging materials
- Serves industries such as e-commerce, food & beverage, and industrial goods
- Located in El Paso, Texas
- Specializes in corrugated box manufacturing
- Equipped with high-speed production lines (e.g., BOBST machines)
- Supplies packaging solutions to regional and national customers
- Key challenges: downtime, setup time, and operational efficiency

Project Objectives

Data Collection

34
Production Runs

126
Downtime Events

8
Variables Tracked

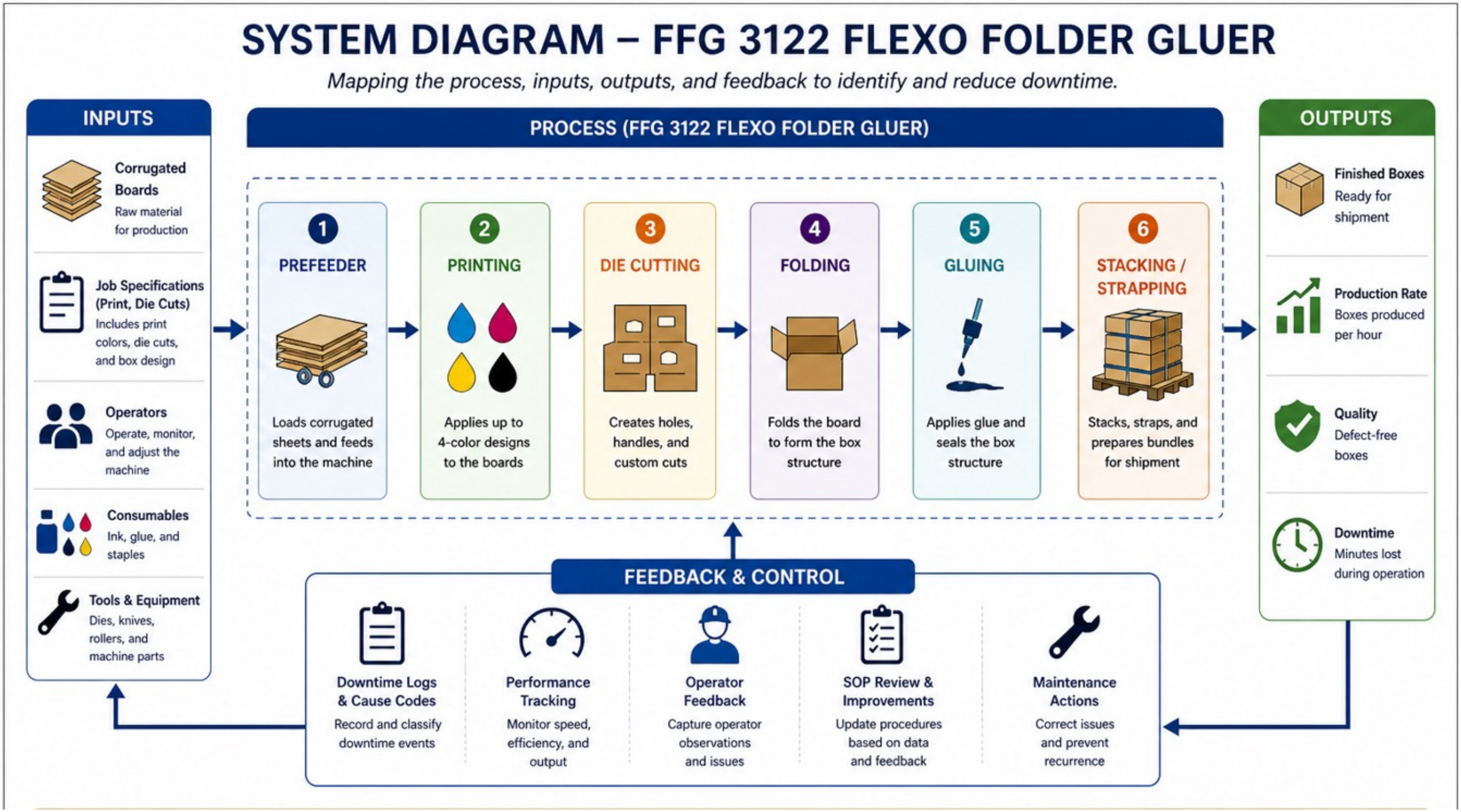
Outcome Variables

- Efficiency
- Total Downtime (Minutes per Run)
- Actual Speed
- Speed Loss

Predictor Variables

- Print Complexity (number of Ink Colors)
- Die Cuts
- Micro-stoppages
- Output (total boards produced)

Data spans June 2025 – April 2026 | Amazon outlier (2× target speed) identified and analyzed separately



SYSTEM DIAGRAM – FFG 3122 FLEXO FOLDER GLUER
Mapping the process, inputs, outputs, and feedback to identify and reduce downtime.
INPUTS
Corrugated Boards
Raw material for production
Job Specifications (Print, Die Cuts)
Includes print colors, die cuts, and box design
Operators
Operate, monitor, and adjust the machine
Consumables
Ink, glue, and staples
Tools & Equipment
Dies, knives, rollers, and machine parts
PROCESS (FFG 3122 FLEXO FOLDER GLUER)
1
PREFEEDER
Loads corrugated sheets and feeds into the machine
2
PRINTING
Applies up to 4-color designs to the boards
3
DIE CUTTING
Creates holes, handles, and custom cuts
4
FOLDING
Folds the board to form the box structure
5
GLUING
Applies glue and seals the box structure
6
STACKING / STRAPPING
Stacks, straps, and prepares bundles for shipment
OUTPUTS
Finished Boxes
Ready for shipment
Production Rate
Boxes produced per hour
Quality
Defect-free boxes
Downtime
Minutes lost during operation
FEEDBACK & CONTROL
Downtime Logs & Cause Codes
Record and classify downtime events
Performance Tracking
Monitor speed, efficiency, and output
Operator Feedback
Capture operator observations and issues
SOP Review & Improvements
Update procedures based on data and feedback
Maintenance Actions
Correct issues and prevent recurrence

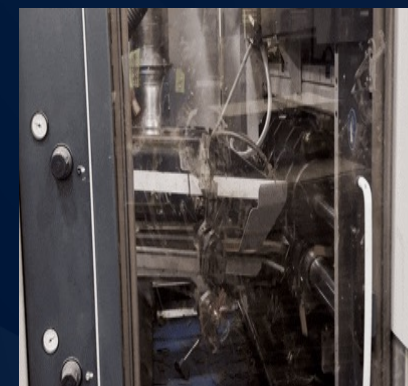
FFG 3122 Flexo Folder Gluer Visual Overview (BOBST)

Corrugated Boards are loaded on to the Prefeeder →

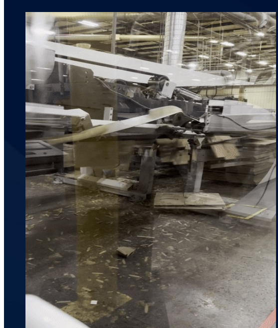
Prefeeder extends corrugated boards and loads them on to the print section →

Print section applies desired graphics and colors →

Die Cut Section makes insertions to corrugated board →



Cutter Section makes insertions for box folds



Fold section shapes the corrugated board →

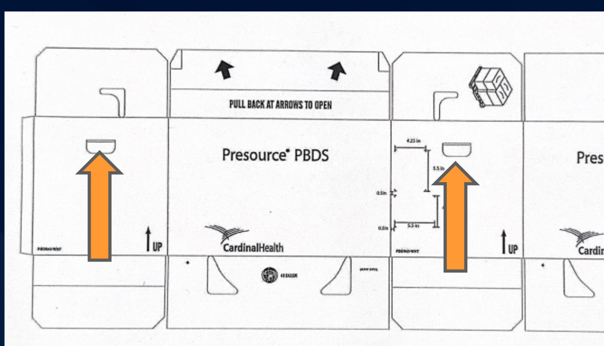
Glue is added to join folded sections →

Stacking Prep Station →

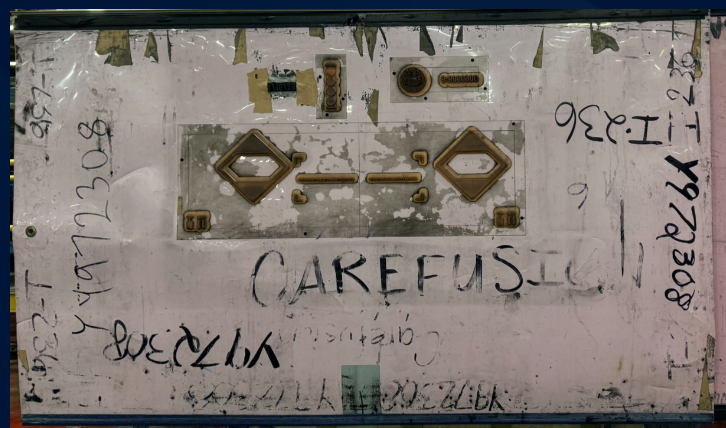
Box Splitter (Optional) →

Strapping Section →

Stacker



Die Cut



Prints

Cutter

PROBLEM STATEMENT & KEY FINDINGS

The FFG 3122 is not consistently meeting target performance levels.

PROBLEM STATEMENT

The FFG 3122 is not consistently meeting target performance levels.

OBSERVED ISSUES

- **Frequent downtime events**
- **Machine jams and interruptions**
- **Inconsistent operating speeds**
- **High variability between production runs**

KEY FINDINGS

High variability between production runs
Not average performance, but inconsistency is the main issue.

Downtime is significant and varies widely across runs
Inconsistent downtime directly impacts output.

Job complexity (print & die cuts) increases downtime
More complex jobs lead to more interruptions.

Higher machine speed does not always result in better performance
Speed alone does not solve the core issues.

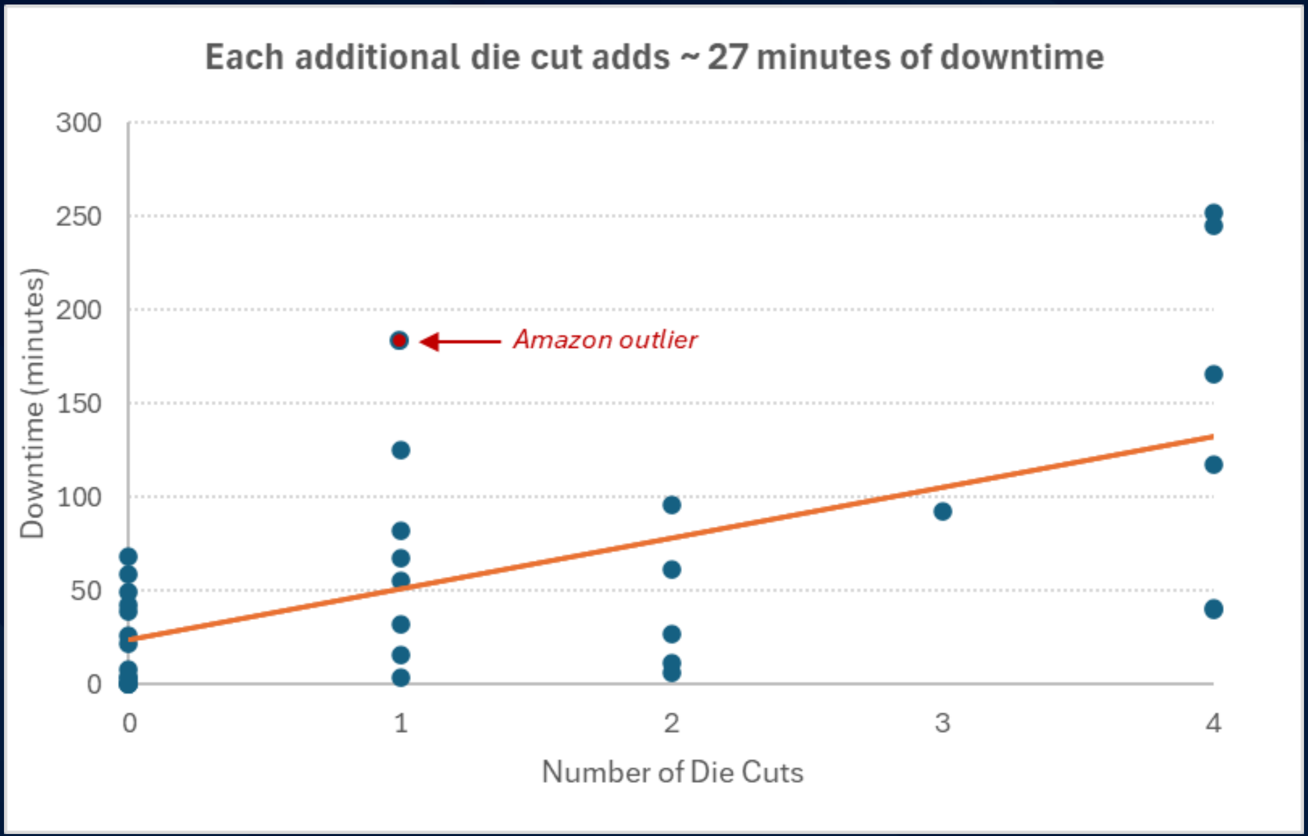
KEY INSIGHT

Performance issues are driven by variability and controllable downtime, not just machine speed.

Regression Analyses

Multiple one-factor linear regression models tested.
Each model run with and without the Amazon outlier.

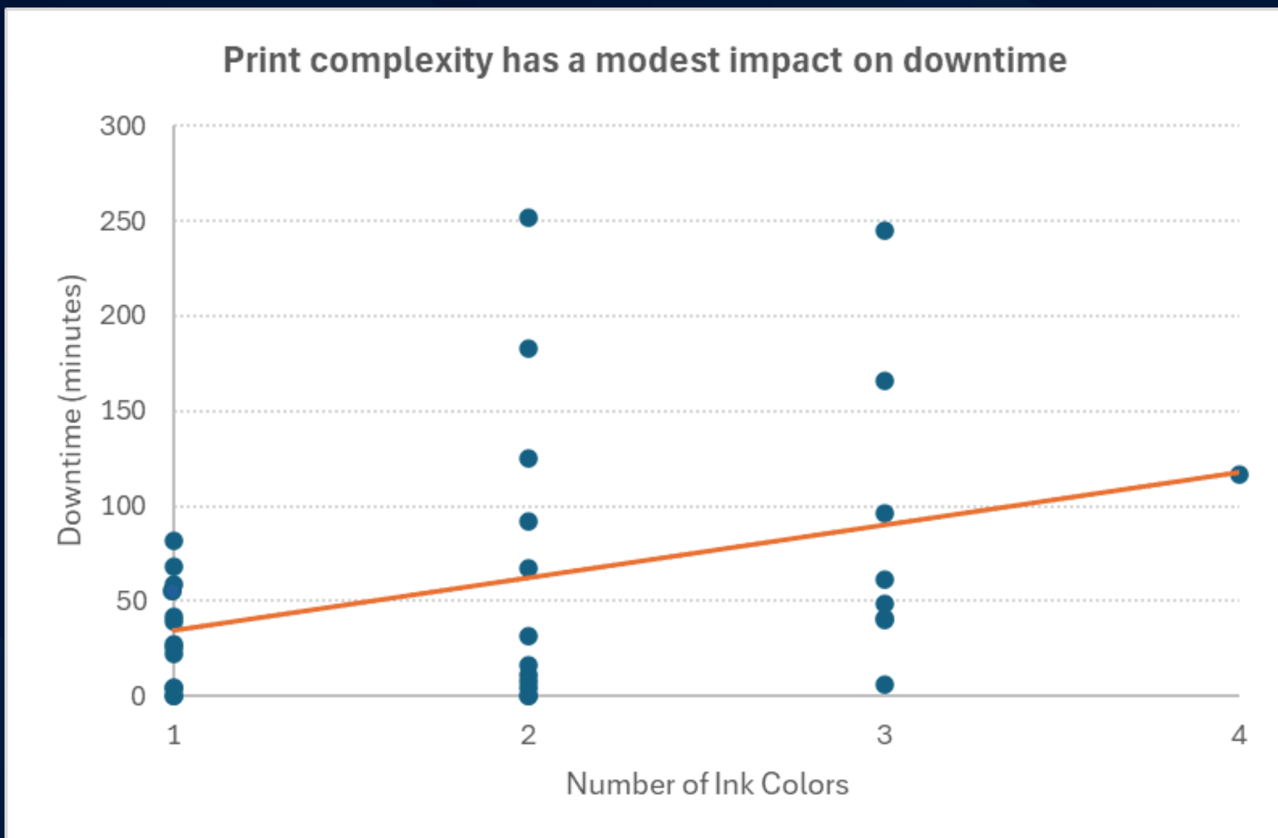
Die Cuts drive Downtime



Model Results

R^2	0.363
P-value	0.0001
Slope	27.060
Intercept	24.155
N	34

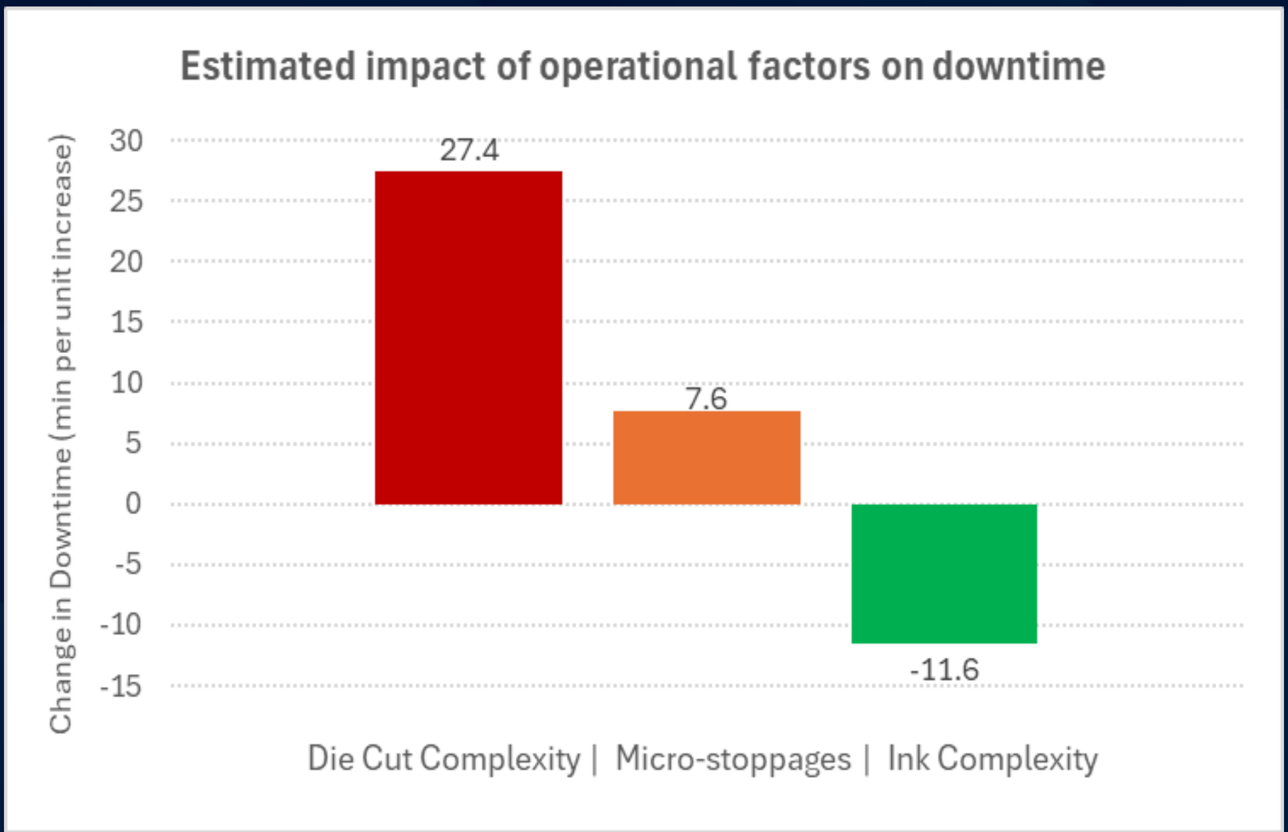
Print Complexity moderately impacts Downtime



Model Results

R^2	0.130
P-value	0.036
Slope	27.892
Intercept	6.648
N	34

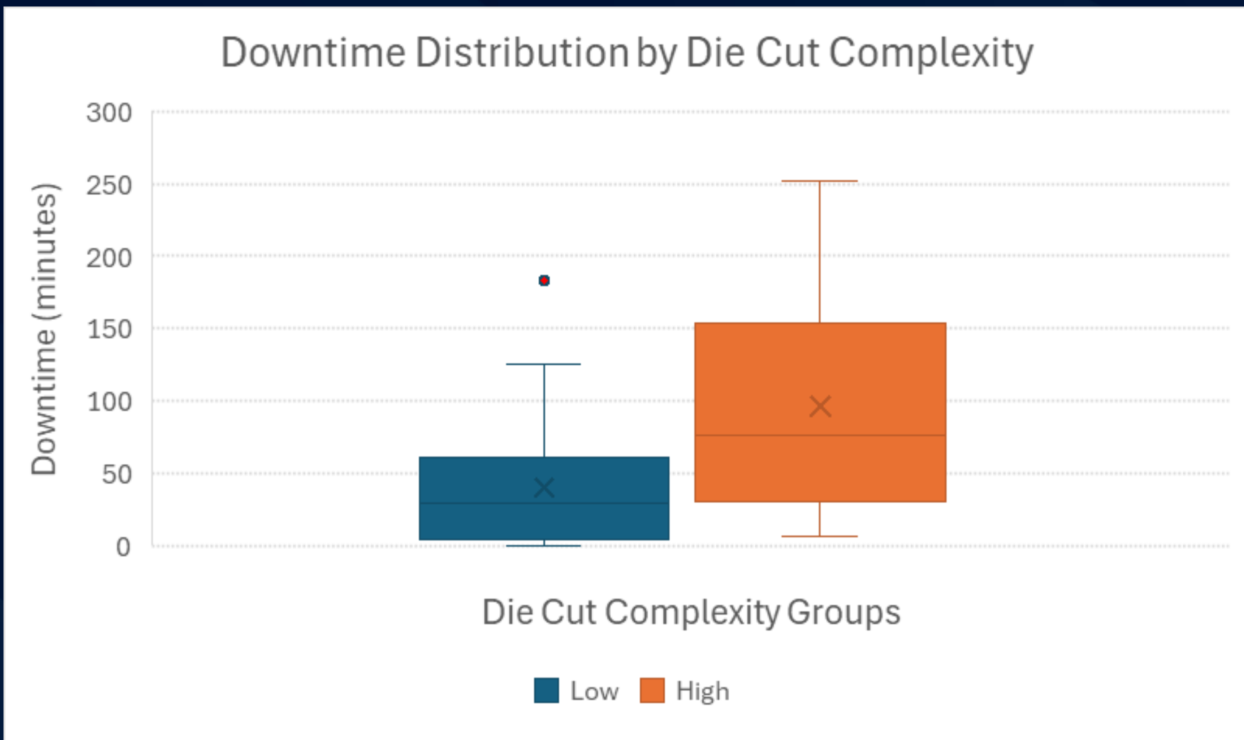
Key Drivers of Downtime Identified Through Regression Analysis



Model Results

R^2	0.461
Adjusted R^2	0.408
Die Cut P-value	0.003
Micro-stoppage P-value	0.031
N	34

Higher Die Cut Complexity Leads to Greater Downtime Variability



Model Results

Low Complexity

N 22

Mean 41 minutes

High Complexity

N 12

Mean 96 minutes

P-value (one-tailed)

0.026

Unequal variances assumed

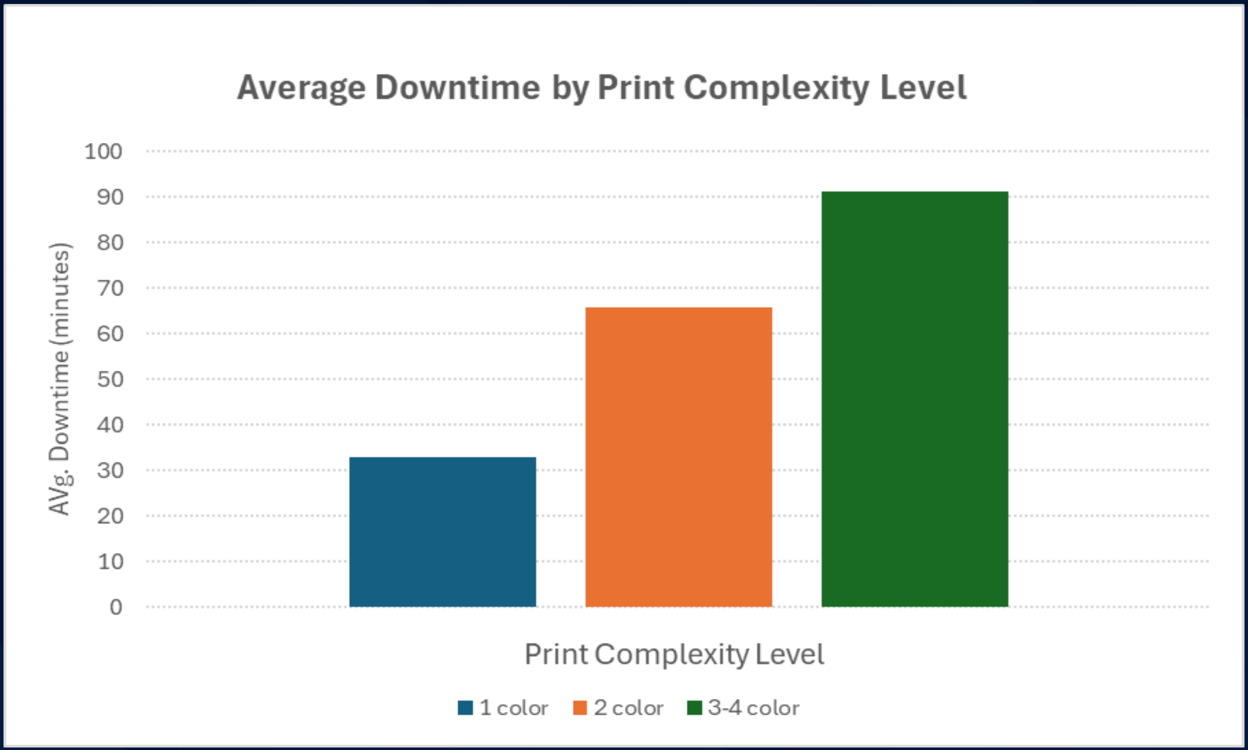
SD

High 84.9

Low 45.1

One-tailed test used due to directional hypothesis supported by regression results

Downtime Varies Across Print Complexity Levels, but Not Significantly



Model Results

Test **One-way ANOVA**

Group Sizes

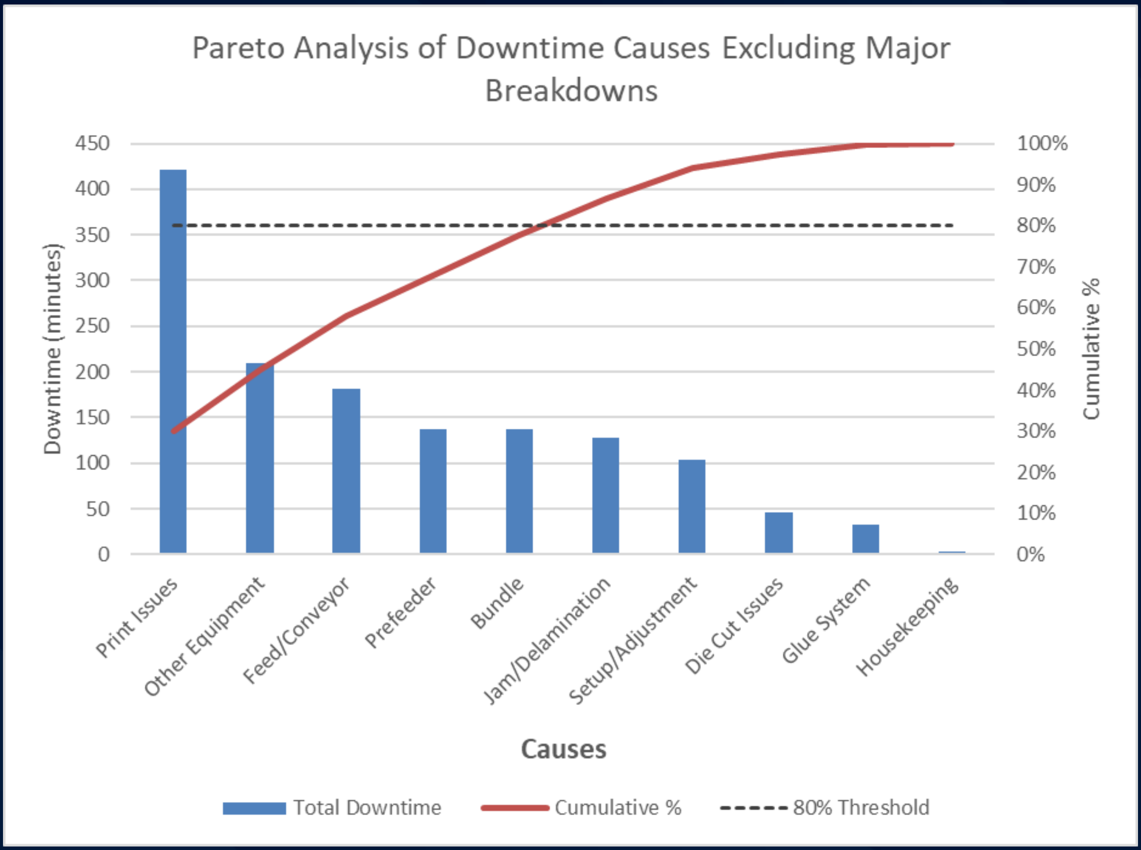
1 color **13**
2 color **12**
3-4 color **9**

p-value **0.122 (not statistically significant)**

f-statistic **2.247**

While average downtime appears to increase with print complexity, ANOVA results indicate that these differences are not statistically significant.

Process-Driven Causes of Downtime (Excluding Major Breakdowns)



Model Results

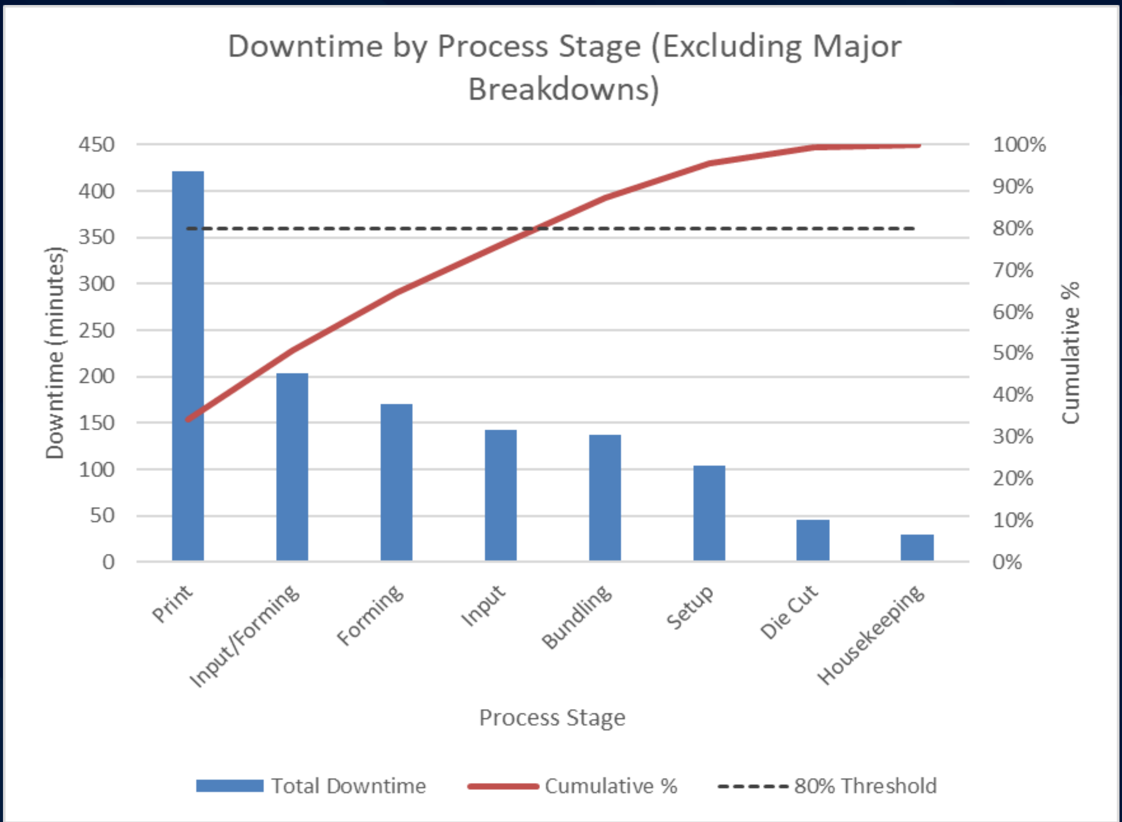
Top contributors
•Print issues
•Equipment
•Feed/conveyor

Represents majority of daily process inefficiencies

Standardized Cause Codes and Process Stage(s)

Cause Category	Process Stage(s)	Examples from data
Prefeeder	Input	Prefeeder jam, prefeeder stop
Jam/Delam	Forming	Jam up, delamination, warp jam
Bundler	Bundling	Bundle tier 1, bundle tier 2
Print Section	Print	Print defect, clean prints
Die Cut/Tooling	Die Cut	Die knife repair, TT knife, die cut section
Feed/Conveyor	Input/Forming	Green belt tracking, twin box slitter, feed section
Glue System	Forming	Glue system fault
Setup/Changeover	All	Adjusting setup, downs, tooling setup
Major Breakdown	All	Major breakdown (>30 min)
Other Equipment	Various	Baler, air pressure, stock unavailable
Scheduled	—	Lunch, breaks, planned maintenance

Process-Level Drivers of Downtime (Excluding System-Level Events)



Model Results

- Print is the largest contributor to process-related downtime
- Input/Forming and Forming are the next major bottlenecks
- Top 3 stages account for ~80% of controllable downtime
- Remaining stages have lower impact and lower priority

The 80% threshold is reached by the first 3–4 process stages, indicating where improvement efforts should be focused.

RUN COMPARISON ANALYSIS

Performance comparison of best, worst and typical runs based on key operational variables.

OBJECTIVE:
Identify the factors that drive efficiency performance.

VARIABLE	BEST RUN *Top Performance*	WORST RUN *Lowest Performance*	TYPICAL RUN *Average Performance*
Efficiency	1.86	0.21	1.00
Downtime (min)	39	49	60
Complexity	Low (1)	High (3)	Medium (2)
Die Cuts	0	0	1
Micro-stops	2	5	4
	Simple process, low complexity and stable performance.	High complexity and interruptions significantly reduce efficiency.	Moderate complexity and controlled interruptions drive average performance.

Ergonomic Analyses

Ergonomic Analysis Approach

- Methods Used:
  - REBA
  - OWAS
  - Task observation & classification
- What We Evaluated:
  - Operator posture and movement
  - Task frequency & duration
- Goal:
  - Identify high-risk tasks
  - Quantify exposure per shift
  - Prioritize improvement

Ergonomic Analysis

- Based on REBA assessment of observed tasks:

Task	REBA Score	Risk Level
Mosca Strap Adjustment	10	Very High
Jam Cleaning	8	High
Die Cut Adjustment	8	High

- Mosca strap adjustment presents the **highest ergonomic risk** and requires immediate action

Ergonomic Risk & Exposure

Task	OWAS Risk (1-4)	Exposure (min/shift)	Priority Rank
Mosca Strap Adjustment	4	4.0	2
Jam Cleaning	3	3.8	3
Die Cut Adjustment	3	1.3	4
Print Section Adjustment	2	9.5	1
Machine Area Cleaning	2	0.1	5

- Total exposure: 18.7 min/shift
- High-risk tasks increase recovery time, while high-frequency tasks drive cumulative downtime

Ergonomics Impact on Downtime

Task	Frequency	Risk Level	Downtime Impact
Mosca Strap Adjustment (Bundler)	10	Very High	Long recovery time, reduced operating speed
Jam Cleaning (Prefeeder + Jam/Delam)	32	High	Extended clearing time due to awkward posture
Print Section Adjustment (Print Section)	32	Moderate	Frequent small delays (cumulative impact)

Mosca Strap Adjustment

Before:
- Bending and twisting, overhead reach
- REBA = 10

After :
- Add side handles + anti-slip platform
- Raise working height

Impact:
- Reduces awkward posture
- REBA ↓ 10 → 6
- Estimated downtime reduction: **~1.6 min/shift (40%)**

Jam Cleaning

Before:

- Deep reaching into machine
- Repetitive bending
- REBA = 8

After:

- Add access panel and long-handled tools
- Standardize clearing steps

Impact:

- Reduces reach and repetition
- REBA ↓ 8 → 5
- Estimated downtime reduction: **~1.4 min/shift (38%)**

Die Cut Adjustment

Before:

- Twisting and awkward posture
- REBA = 8

After:

- Reposition controls for front access
- Add **guide rails**

Impact:

- Reduces twisting and movement
- REBA ↓ 8 → 5
- Estimated downtime reduction: **~0.5 min/shift (38%)**

Estimated Impact on Downtime

- Total estimated reduction: ~ 3-3.5 min/shift
- Highest impact tasks: Jam cleaning and Mosca strap adjustment
- Improvements address both:
  - High-risk tasks → faster recovery
  - High-frequency tasks → reduced repeated delays

CONTROL PLAN

Monitor, Standardize, and Hold the Gains

1. MONITORING

Track boxes per minute (performance)	Monitor actual speed vs. target
Track downtime per run	Monitor total downtime and downtime causes
Monitor repeat issues (jams, setup problems)	Identify recurring problems and root causes

2. CONTROL TOOLS

Daily operator checklist (SOP compliance)	Ensure critical checks are completed every shift
Run charts / control charts for performance	Visualize trends and detect early deviations
Downtime tracking log	Record downtime events, duration, and corrective actions

3. STANDARDIZATION

- Implement SOP across all shifts
- Train operators on consistent procedures
- Define clear roles and responsibilities

4. ACCOUNTABILITY

- Assign a process owner / supervisor
- Review performance regularly (daily / weekly)
- Address recurring issues systematically and track actions

5. KEY IDEA

Sustained improvement requires monitoring, standardization, and accountability.

GOAL: Maintain stable performance, minimize avoidable downtime, and continuously improve efficiency.

Consistent Performance | Less Downtime | Fewer Disruptions | Continuous Improvement

Standardized Pre-Run Checklist Based on Process Risk

Pre-Run Checklist

Job ID: ______ Operator: ______

Date: ______ Die Cuts: ______

Print Colors: ______

Risk Classification

- ☐ Die Cuts ≥ 2
- ☐ Print ≥ 2 colors
- ☐ High-risk stages (Print/Forming/Feed)

Classification: ○ High Risk ○ Standard

High Risk Preparation

- ☐ Inspect die tooling
- ☐ Verify print system
- ☐ Inspect feed/forming/output
- ☐ Check material

Standard Preparation

- ☐ Setup complete
- ☐ Material OK
- ☐ Settings verified

Pre-Run Validation

- ☐ Test batch run
- ☐ Feed stable
- ☐ Cuts accurate
- ☐ Print acceptable
- ☐ No jams/stoppages

Adjustments

- ☐ Reduce speed
- ☐ Adjust alignment
- ☐ Fix tooling

Operator Communication

- ☐ Communicated job risk
- ☐ Reviewed issues
- ☐ Response plan set

Notes: ______

EXPECTED IMPACT

Improving Consistency, Reducing Downtime, Increasing Value.

1. OPERATIONAL IMPACT

Reduce downtime events	Focus: performance stability
Improve machine efficiency consistency	Focus: performance stability
Increase throughput (boxes per minute)	Focus: performance stability

2. PROCESS IMPROVEMENTS

Reduce variability between runs	Focus: process control
Better handling of complex jobs	Focus: process control
Fewer micro-stoppages	Focus: process control

3. COST & EFFICIENCY

Reduce tooling wear (die cuts, components)	Focus: cost optimization
Fewer production delays	Focus: cost optimization
More predictable output	Focus: cost optimization

4. PERFORMANCE OUTCOMES

Less downtime	→	More uptime
Higher throughput	→	More output
Lower costs	→	Better resource use

5. KEY IDEA

Stable operations + controlled variability = higher efficiency, lower cost, and greater value.

Higher Efficiency | Less Downtime | Fewer Disruptions | Continuous Improvement

CONCLUSION

Key Insights. Strategic Actions. Sustainable Results.

1. WHAT WE LEARNED

1. VARIABILITY IS THE MAIN ISSUE
The FFG 3122 operates with high variability, not consistently at target performance.

2. JOB COMPLEXITY DRIVES DOWNTIME
Print and die cut complexity increase setup time, micro-stoppages, and reduced efficiency.

3. DOWNTIME IS LARGELY CONTROLLABLE
Most downtime comes from repeat and systematic issues, not random events.

4. LACK OF STANDARDIZATION CREATES GAPS
Inconsistent actions and decision-making lead to different results between runs and operators.

2. THE BIG PICTURE

Stable processes create predictable results.

Less Downtime
More uptime for production

Higher Throughput
More boxes per minute

Consistent Performance
Reliable results across runs

Lower Costs
Less waste, fewer delays, better ROI

Consistency is the foundation of efficiency and long-term operational excellence.

3. FINAL MESSAGE

Stabilizing the process through standardization is more impactful than simply increasing machine speed.

4. RECOMMENDATION

Implement SOPs and align operations with job complexity to drive consistent, predictable, and high-performing results.

"The goal is not faster production — it's stable, consistent, and reliable performance every time."

We would like to personally thank…

Dr. Arunkumar R. Pennathur

Sr. Director Juan Soto

General Manager Hank W. Wickens

Environmental Health & Safety Manager Eliazar Alvarez

Station Manager Roberto Perez

&

All of Smurfit Westrock El Paso staff

THANK YOU

Questions?

Ivan Garcia | Viridiana Martinez | Andrea Ortiz | Bryan Trevizo

Senior Design | Smurfit Westrock, El Paso