

FANUC

THE FACTORY AUTOMATION COMPANY

Efficiency in Manufacturing Supported by FANUC

By

Dr. Wilfried Steiger

Content of Presentation

Traditional Manufacturing System

Efficiency (metrics and measures)

FANUC's Digital Twin Concept

- CNC GUIDE 2

- SERVO VIEWER Surface Estimation

- CNC Parameter Adjustment Supporting Function

- NC Reflection Studio (NCRS)

- Photorealistic Machine Tool Simulation

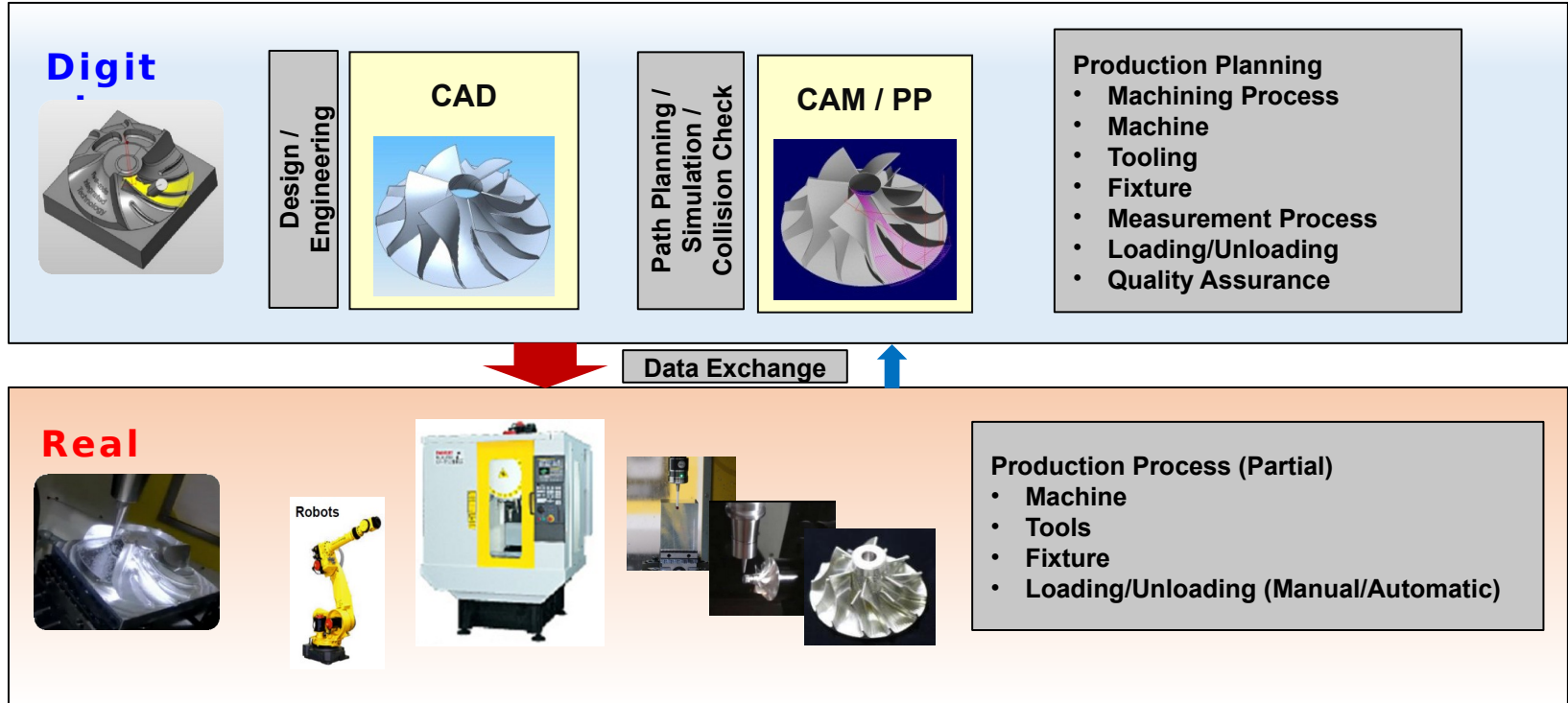
- QSSR AUTO PATH

Environmental Load Reduction

Bridging the Gap

Conclusion

Traditional Manufacturing Chain Elements



Efficiency in Manufacturing

KPI for Manufacturing Efficiency (Metrics - selection)

- Right First Time
- Production Time / (Production Time+Non-Scheduled Production Downtime)
- Production Time / Maintenance Requirements
- Environmental Load Reduction at same or higher output

Efficiency improvement factors:

- Reduce Errors – by removal of error sources
- Optimize Process / Process Flow
- Adapt Process to environment or environment to process
- Control (collect data, review, improve)

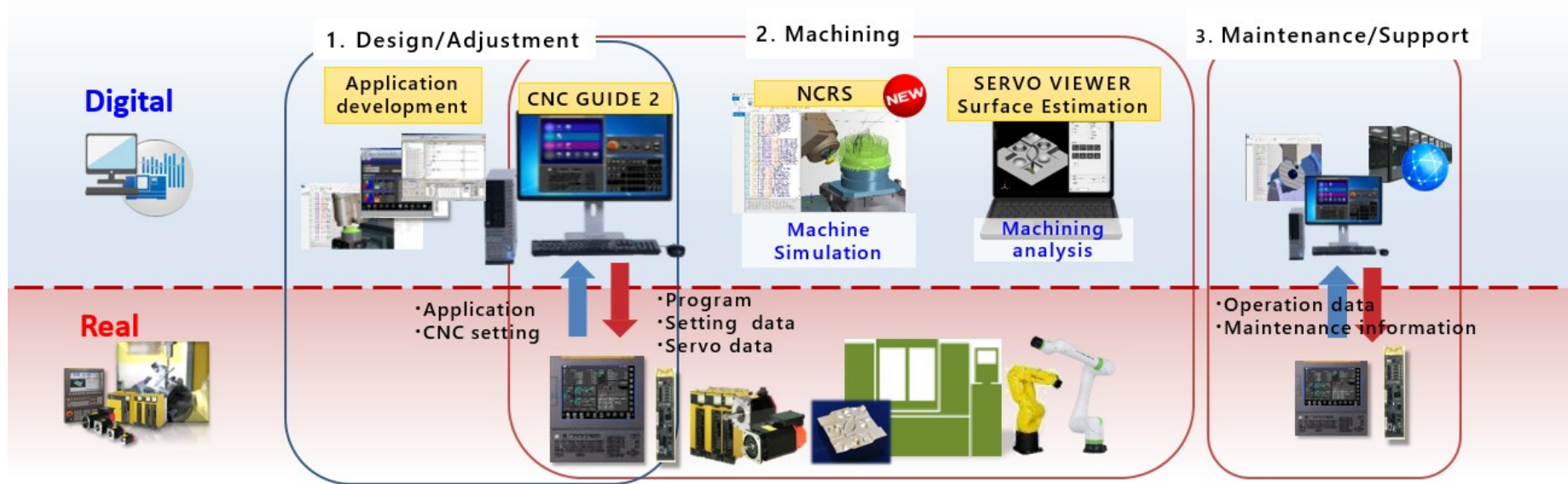
$$\text{Efficiency} (\eta) = \frac{\text{Output}}{\text{Input}}$$

Ref.: Oxford Languages

Efficiency Gain: FANUC's CNC Digital (Twin) Concept

Productivity and Efficiency for Machine Tool Builders and Machine Tool Users

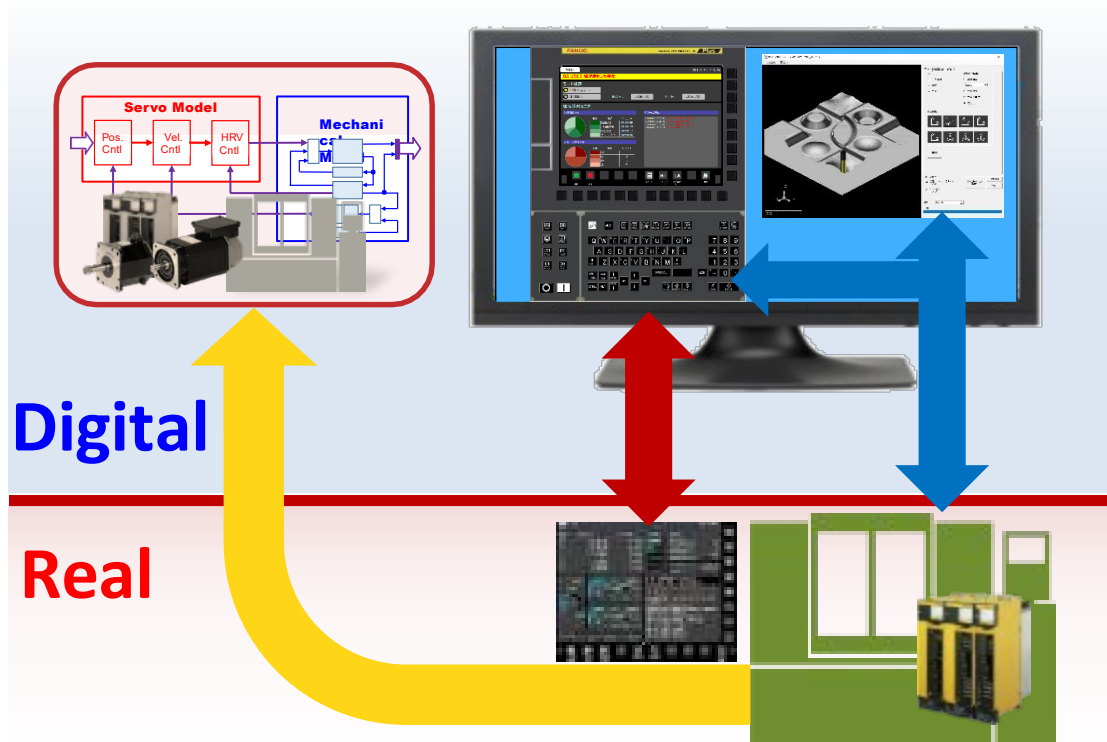
Training / Development / Planning / Verification / Maintenance Support



Fast Simulation Model: CNC GUIDE 2

Fast Simulation based on Servo Mechanical Model

- Servo Mechanical Model presents characteristic of each axis as truthfully as possible
- Reduction of time required for trail cutting, by estimating resulting surface truthfully.
- Fast Simulation cycles reduce test time significantly compared to real machine
- Supports optimization of CNC Settings
- Supports verification and optimization of part program
- General Process optimization



Quick Analysis: SERVO VIEWER Surface Estimation

Digital



SERVO VIEWER Surface Estimation

Verifying position data without real machine tool

Virtual Position

Real Position

Real



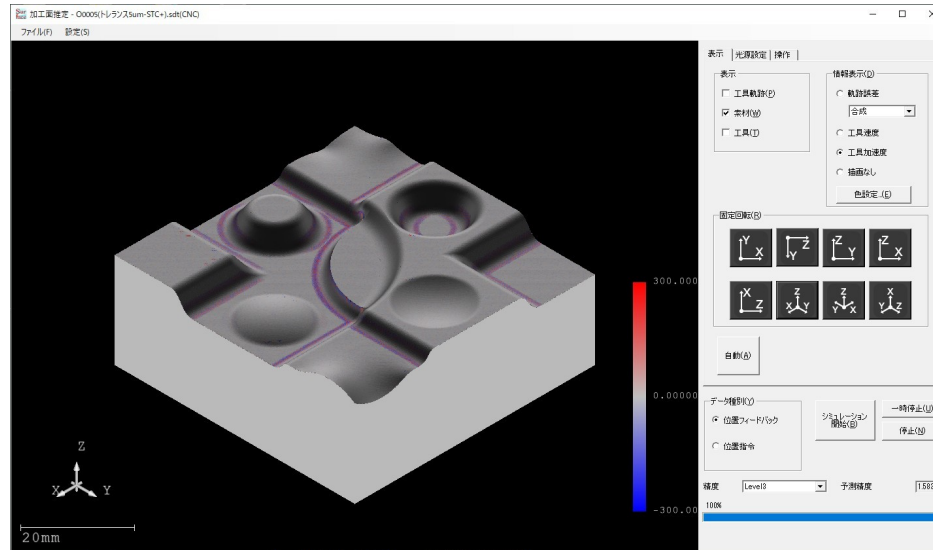
AirCut Real Machine

Confirming the machining surfaces without trial cutting

Trial Cutting
(Photograph)

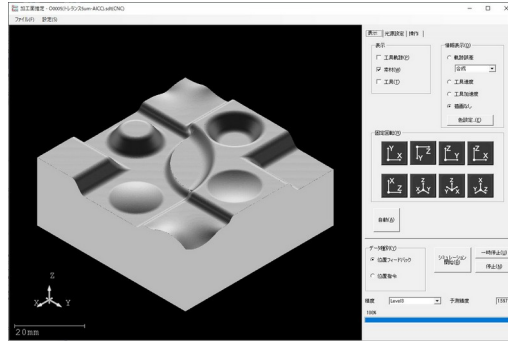
Real position data
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Advanced Process Analysis: Surface Estimation - Information Rendering



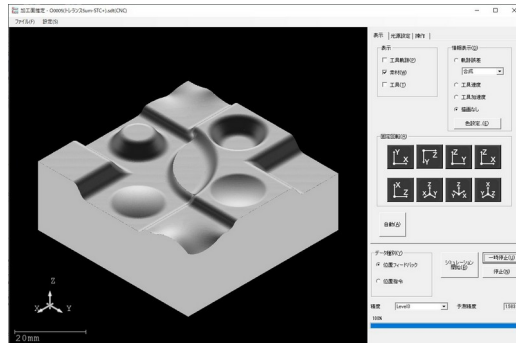
Display: Tool Acceleration in Color Gradation

Efficient Setup Analysis: Surface Estimation - Surface Deviation Rendering

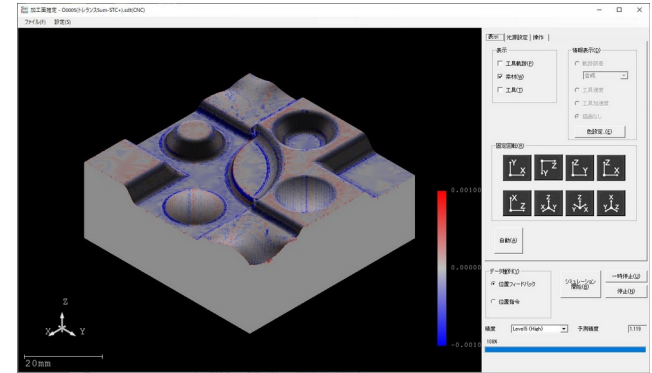


Result **Before** Adjustment

Compare



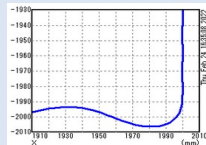
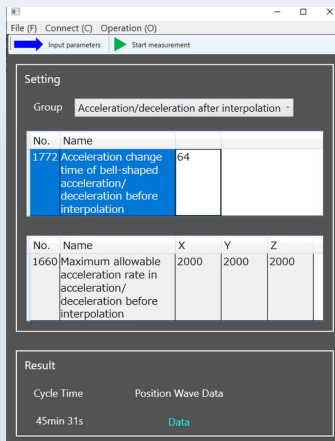
Result **After** Adjustment



Setup Verification: CNC Parameter Adjustment Functionality

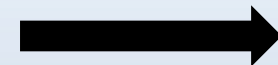
Digital

CNC Parameter Adjustment Supporting Function



SERVO GUIDE

Set Parameter



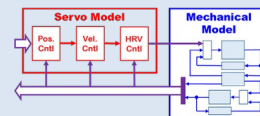
Confirm Results



CNC GUIDE 2

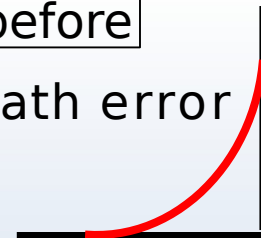


Servo Mechanical
Model



before

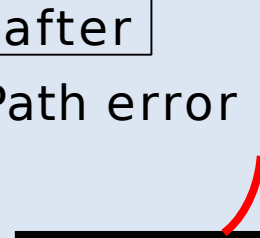
Path error



long cycle time

after

Path error



short cycle time

Powerful Visualization: NC Reflection Studio (NCRS)

Machine Simulation & Collision Check supporting CNC GUIDE 2 / Real CNC

- High Speed Execution
- Safe Operation
- CNC GUIDE 2 provides accurate machining path, by considering effects of acc./dec.

Benefit

- Accurate machining Program Check
- Actual machine available for production

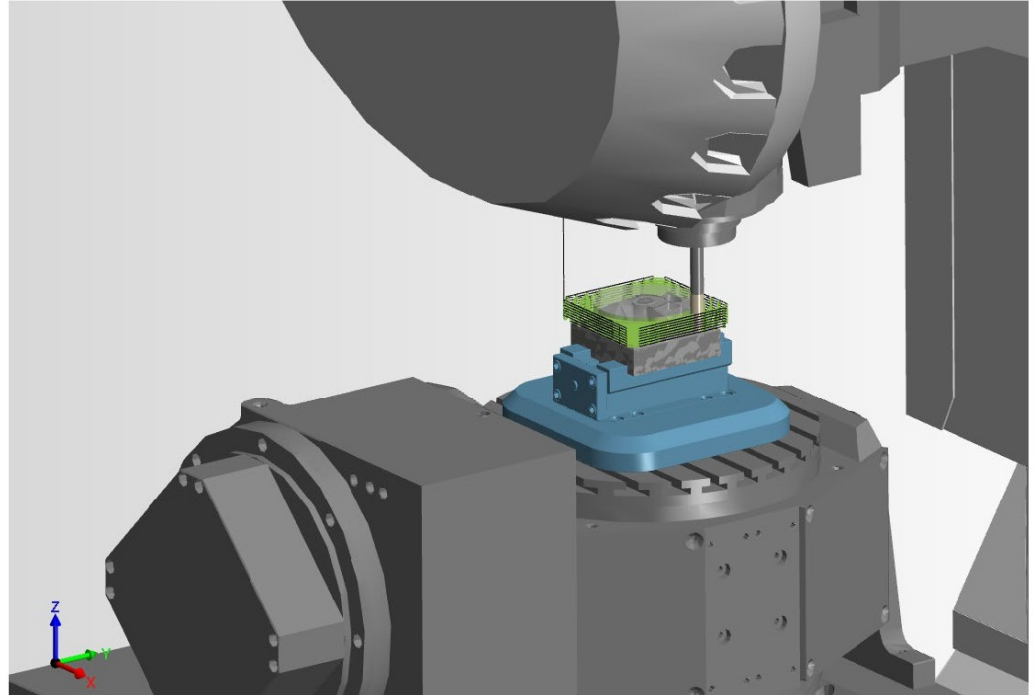
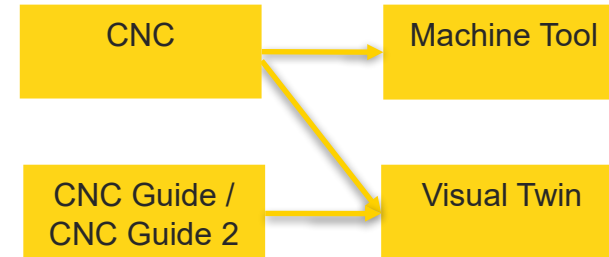
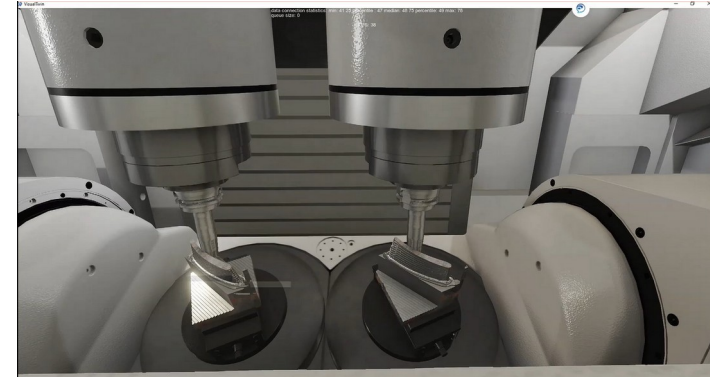


Photo-Realistic Visualization - Visual Twin Concept

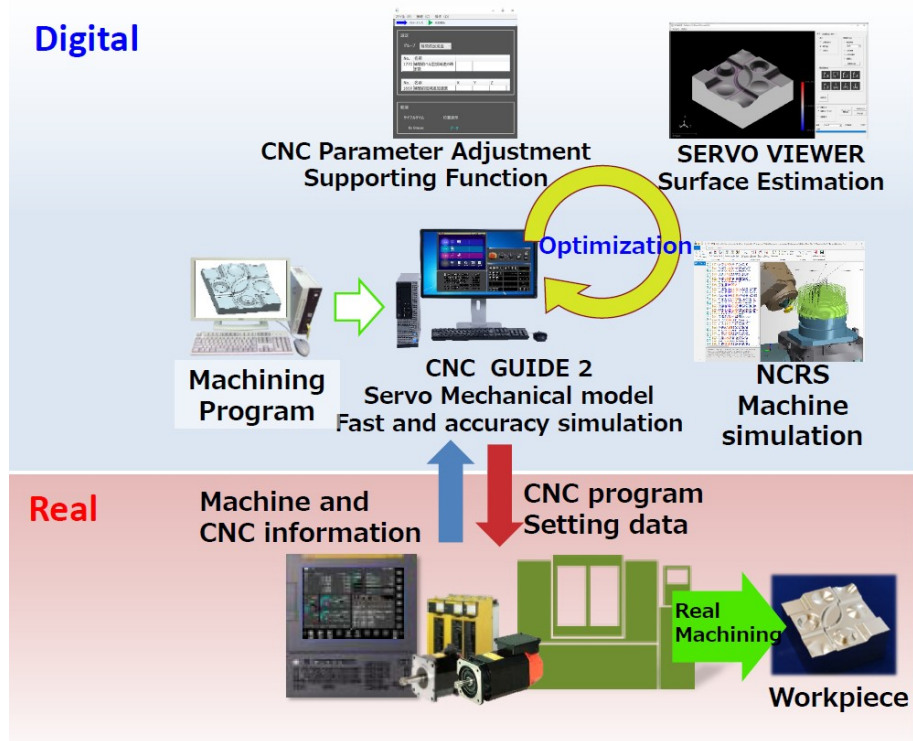


Time Saving Adjustment of Machining Conditions: Machining & Process Optimization by Digital Twin

Fast and efficient adjustment of the machining condition

Applications optimize machining condition, using virtual position data output by CNC GUIDE 2

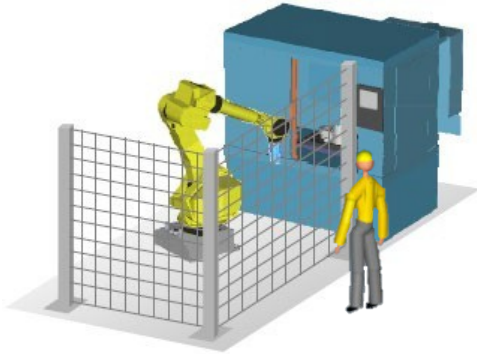
- CNC Parameter Adjustment Supporting Function
- SERVO VIEWER Surface Estimation close to Real results
- NCRS Enabling accurate machine Simulation



Quick and Save Automation: QSSR AUTO PATH

CNC GUIDE

Machine tool user



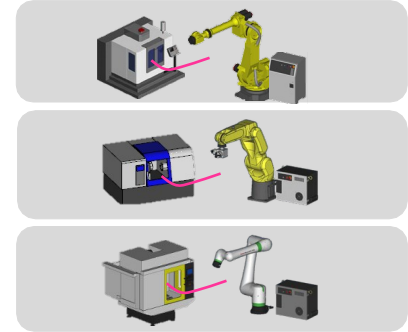
Program generation and
confirmation on office
PC



QSSR
AUTO PATH

ROBOGUIDE

Machine
tool
builder/SI



Simulation with
multiple
systems

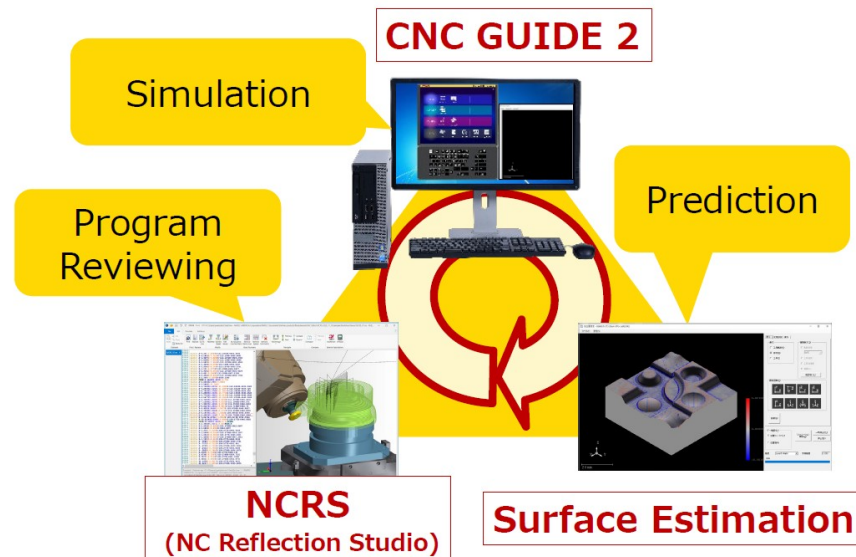
Digital Twin Propels Environmental Load Reduction

Digital Twin (Simulation) saves:

- Power
- Material
- Tool Wear
- Oils and Fats
- ...

Therefore

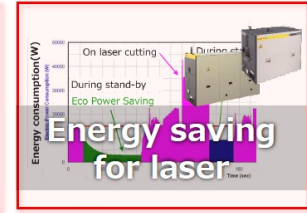
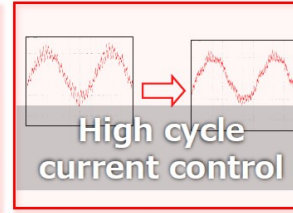
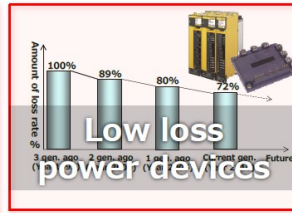
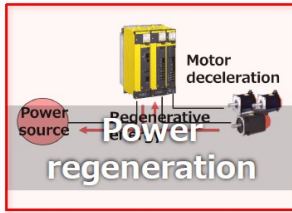
- Reduces environmental load by increasing efficiency of system
- Contributes to environmental management systems



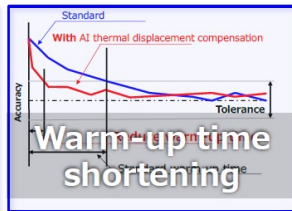
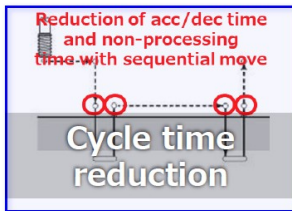
Trial processing on Digital Twin

Advanced Technologies for Efficient Energy Conservation

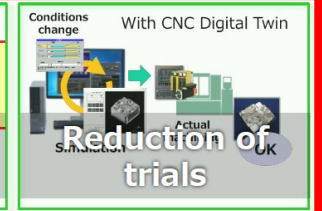
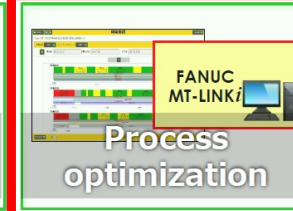
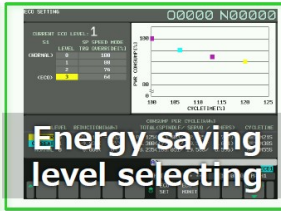
Energy consumption related to machining



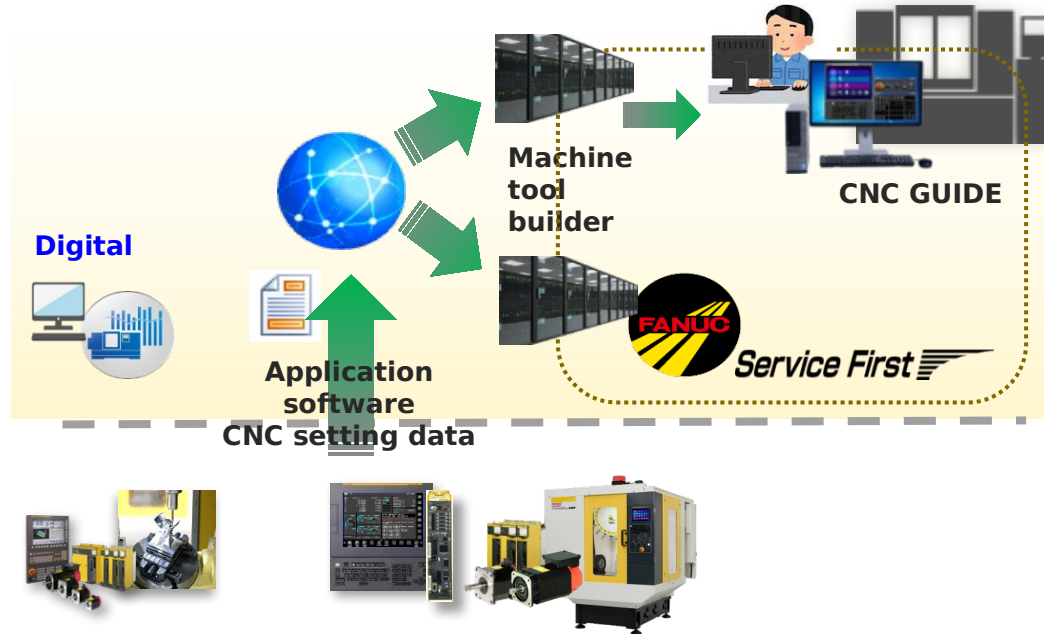
Energy consumption related to operating time



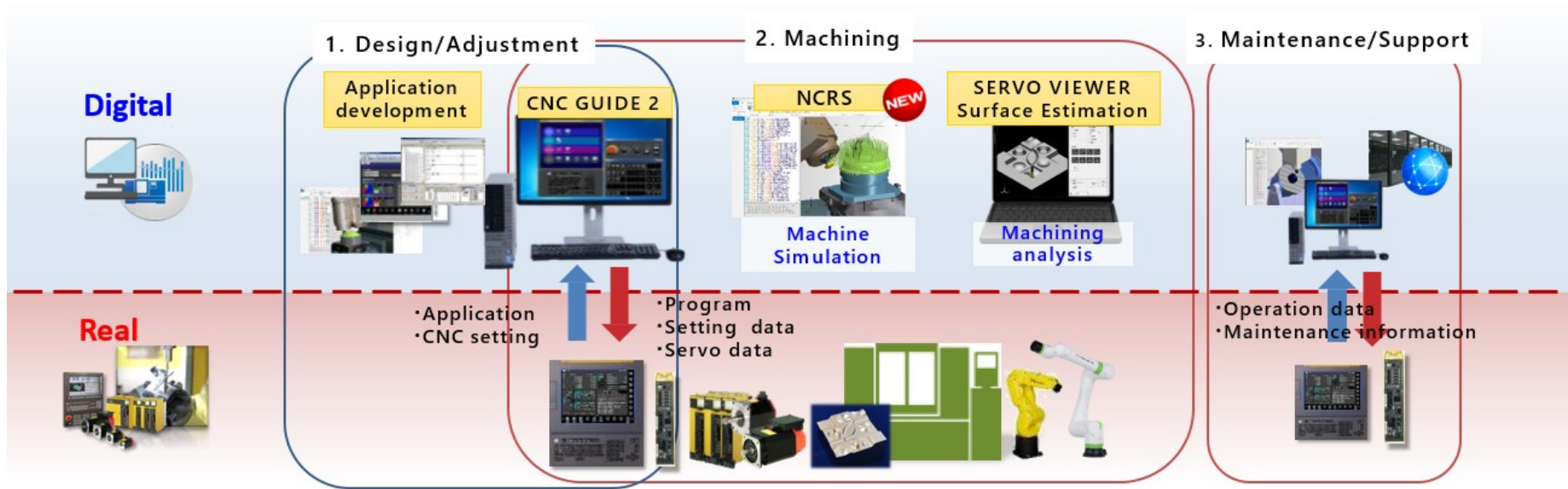
Energy consumption in whole machining process



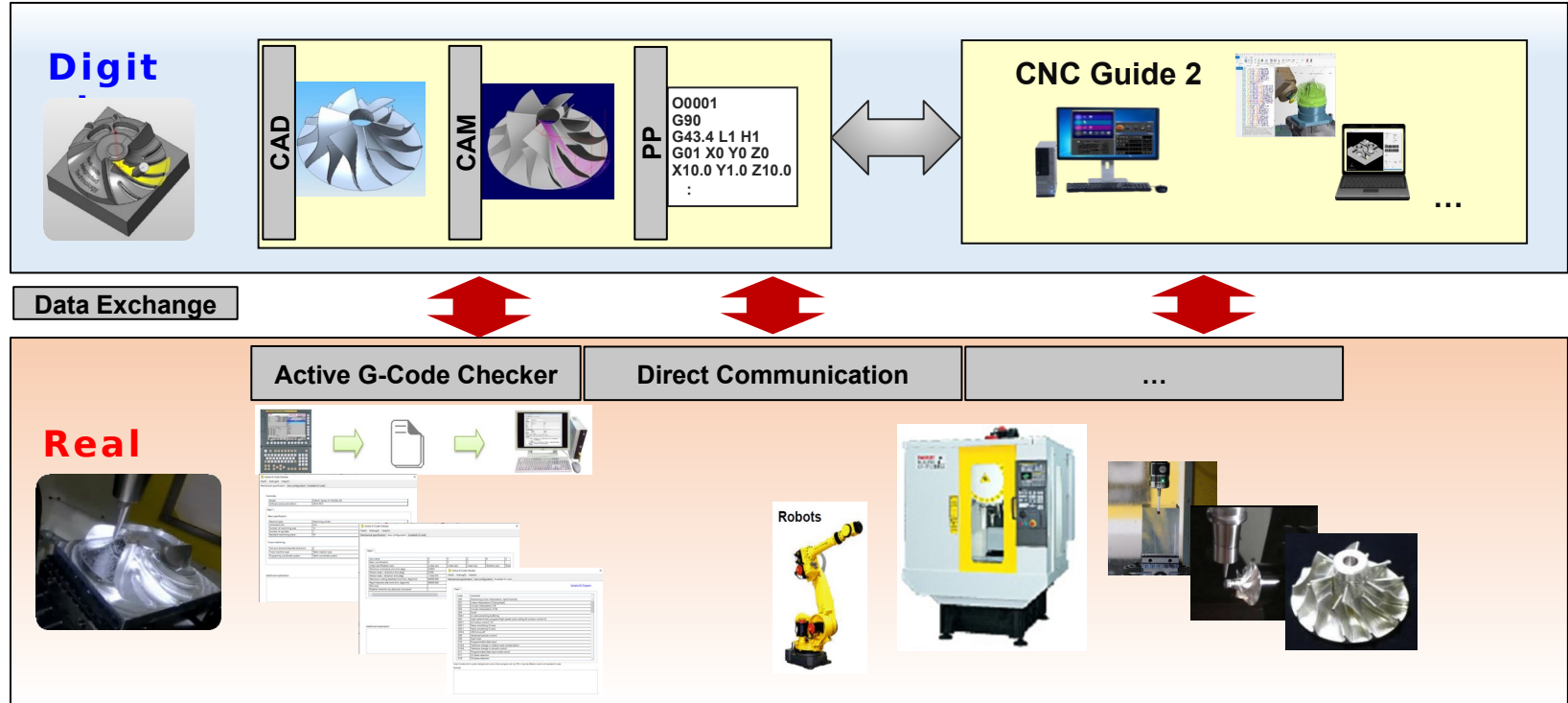
Reducing Downtime: Maintenance Support



Efficiency Gains: Bridging Digital and Real World

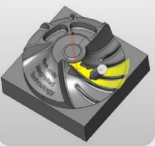


More: Bridging the Gap



More: Bridging the Gap

Digit





CAD

Data Exchange

Active

Real



Active G-Code Checker

File(F) | Setting(S) | Help(H)

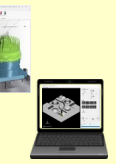
Mechanical specification | Axis configuration | Available G-code

Sample NC Program


Code	Comment
G00	Positioning (Linear interpolation, rapid traverse)
G01	Linear interpolation (Cutting feed)
G02	Circular interpolation CW
G03	Circular interpolation CCW
G04	Dwell
G04.1	G code preventing buffering
G05	High-speed binary program/high-speed cycle cutting (AI contour control II)
G05.1	AI contour control I/II
G05.1	Nano smoothing (3-axis)
G05.1	Nano smoothing (5-axis)
G05.4	HRV3,4 on/off
G08	Advanced preview control
G09	Exact stop
G10	Programmable data input
G10.8	Tolerance change in rotation axes compensation
G10.8	Tolerance change in smooth control
G11	Programmable data input mode cancel
G17	XY plane selection
G18	ZX plane selection

Note: G-code which is yellow background is set to Macro program call by MTS. It may be different motion with standard G-code.

Format



...



Conclusion – Efficiency Improvement Factors

Main factors improving Manufacturing Efficiency by Digital Support
And sufficient Bridges between Digital and Real World

- Capture Environment
- Operator Training
- Operation / Process Visualization
- Process Optimization
- Part Program Verification
- (Real-Time) Collision Avoidance
- Estimated Surface Verification
- Maintenance Prediction / Analysis

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