REPLACING AND MODERNIZING A LEGACY CONTROL SOLUTION

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Motivation

Increasing process complexity and a high product mix at legacy fab require tighter process control than delivered with an existing solution.

• The current platform does not meet requirements for advanced control logic.
• It is also not extensible to address a rapidly changing manufacturing or factory systems environment.
• It is a point solution that is not able to be proliferated to other modules.
• The current system is no longer supported, and changes to the current system are therefore not possible.

A replacement Process Control Framework (PCF) is therefore needed to close the gaps and facilitated further APC investment.
INFICON is contracted to replicate the existing solution while demonstrating support and extensibility for future enhancements.

- Success criteria based on matching POR control decisions, i.e. “apples to apples.”
- Extract, transform, load and leverage existing controller configuration data.
- Extend (as needed) core framework capability to support existing requirements.
- Flexibility in supporting operation scenarios with new user interfaces and/or API to facilitate internal development of solutions.

Closed-Loop Implementation ~ 6mo. mark

Requirements Definition
Development
Configuration and ATP
Open Loop Testing
Closed-Loop Implementation ~ 6mo. mark
Parallel Deployment

Deployment was to begin in parallel operation with the existing solution.
• Closed-loop control was still provided by the existing solution.
• Open-loop control with the new PCF, acting in a “listening mode,” facilitated state initialization.
• Responses from the new PCF were recorded on both sides for validation and comparison.
Integration

E133 standard messages were used to facilitate clear sequence and structure.

- The customer was required to parse needed information from MES and tool.
- HTTP calls were also developed and integrated into tool controllers.

The project benefitted from existing customer expertise with control systems integration and operational use cases.

- Includes all needed tool communications, e.g. recipe adjust, metrology report parsing, etc.
Roles and Responsibilities

INFICON
• PCF installation
• E133 integration and documentation
• Controller development (replication)
• Metrology modeling / filtering
  • Replace exiting 3rd party solutions
• Migration of controller configuration
• Business rule replication
• Open-loop deployment
• Training

Customer
• CIM message development
• Parallel messaging to new PCF
• Metrology raw data collection
• Control job logging
• Standalone assessment tool
• Operational scenario development for engineering / sustaining personnel
• Closed-loop migration

Replacing and Modernizing a Legacy Control Solution
Success Criteria

- Assessment compared results on a per-lot basis to note deviation between sets of recommendations.
- Initial comparison data provided through novel control logs developed within the new controller and framework, e.g. used parameters vs. new recommended parameters.
- Customer later developed a standalone system to collect and report feedback from both systems for more comprehensive comparison.
  - Facilitated visibility to exiting system, e.g. rules violations, execution errors, etc.
  - Highlighted cases of manual overrides, inadequate MES data, and other exceptions
  - Tracked state estimation strategy and used data sets
  - Select configuration information also assessed, e.g. target, process sensitivity, etc.
Project Execution

• Metrology modeling and filtering straightforward
• Open loop data collection (used recipe settings and metrology results) quickly implemented and changed relatively little from initial design
• Plant / control model development simple to complete
• Business rules, both existing and novel, clear and not difficult

• Existing controller configuration data voluminous, cumbersome to replicate
  • Challenge with both the parameter data and the lookup methodology
  • Represented largest delays in project execution
  • Validation necessitated development of the standalone comparison tool
• State estimation used data with expiration up to 120 days, meaning even three month open-loop testing not sufficient in all cases for data replication
• Assessment ultimately needed to include simulated control performance – simple replication was neither necessary nor sufficient success criteria.
Validation
Exposure Control

- Recipe adjustments were compared to validate replication of existing control.
- Majority of runs < 1% deviation
- Significant differences (> 4%) seen in cases of data poverty, e.g. lower-running parts, new product introduction
- Actual (existing) vs. projected (new) CD results were also compared
- Rework logic purposefully changed to improve performance
- Mixed in terms of improvement (green) vs. degradation (yellow)
Validation
Overlay Control

Overlay results were similar to those evident in the CD portion of the control strategy.

- Excellent replication of modeled Overlay error and corrections was seen when using same data set.
- Data poverty and altered rework logic saw modest to significant differences, split again between improved and degraded control.
Validation

CD Histograms

Rework + Ample Data
1% stdev reduction

All runs
63% stdev increase*

*Significant outliers seen when both frameworks had data poverty, and new system had limited history. Initialization strategy is an anticipated area of future improvement.
Lessons Learned

• Project role and responsibility definition was key for project execution.
  • Project communication ownership, cadence and stakeholder list
  • Task identification, assignment and due dates
  • Ownership of solution development on each side of systems integration
  • Stakeholder review for delivery acceptance

• Support is needed from all stakeholder groups.
  • Module engineering: requirements definition, control budgets, controller configuration, business processes adaptation
  • CIM: framework specifications, integration development, remote access
  • Management: sponsorship, resource allocation, project management
Lessons Learned

• Success criteria should be strictly defined and match expectations.
  • Replication was easier to define, but control performance was the needed metric.
  • Improvements in replication were time-consuming, and future development may ultimately deprecate much of the logic in favor of control improvements.

• Parallel operation of two systems required regular synchronization.
  • Process history was decided to be accumulated over time in open loop mode, though this lead to slower convergence over time.
  • Configuration data is continuously updated in the existing system, and therefore needed to be replicated to new solution on a regular bases (now daily).
  • Data invalidation remained a challenge, as user tools for said only operated against the existing solution.
Lessons Learned

• Access to the existing control solution benefits new development
  • Technical documentation of feature set and capabilities
  • Configuration parameter set and current settings
  • Run logs for included data, business rule application and exceptions
  • Basis for control parity validation for both scope and results sets

• Names matter!
  • Nomenclature needs alignment, especially among tool controller and both control systems
  • Translation should be decided and documented before development to avoid rework
  • Begin with the end in mind – the new solution is intended to set future standards
  • Error codes and messages should be included in in standardization, both in terms of names and agreement with operational support
Next Steps

• Current Project has completed Open Loop acceptance testing.
• Project timeline on track for seven months to initial closed-loop control release, primarily delayed by configuration data ETL.
• Closed-loop testing has a set up supporting deliverables.
  • Automated Test Plan for both core framework capabilities as well as controller logic.
  • Training plans for administrators, engineering and operator roles
  • Review and possible alteration of operational scenarios
    • Troubleshooting and port-mortem analysis
    • “What-if” control job user interface
    • Control and data logs review for completeness and accuracy
    • Limited release planning and roll-out schedule
• Post-project improvements also anticipated, though not yet defined.
Thank you!