REPLACING AND MODERNIZING A LEGACY CONTROL SOLUTION

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Motivation

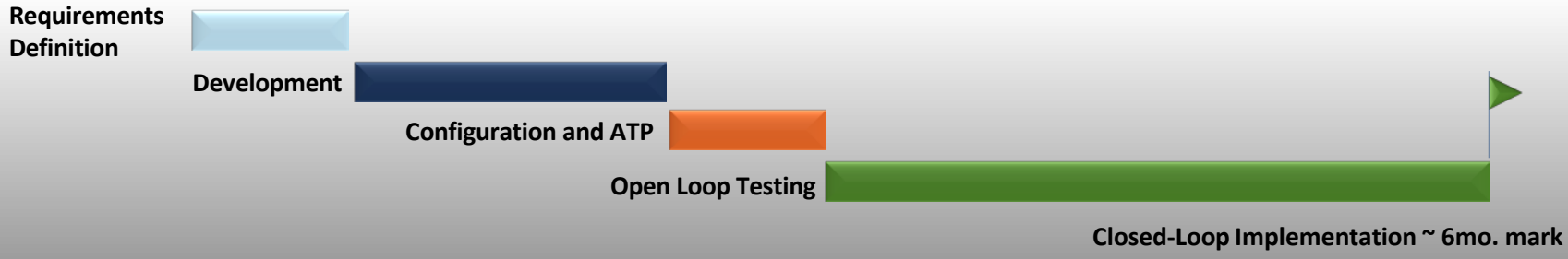
Increasing process complexity and a high product mix at legacy fab require tighter process control than delivered with an existing solution.

- 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.

Project Charter

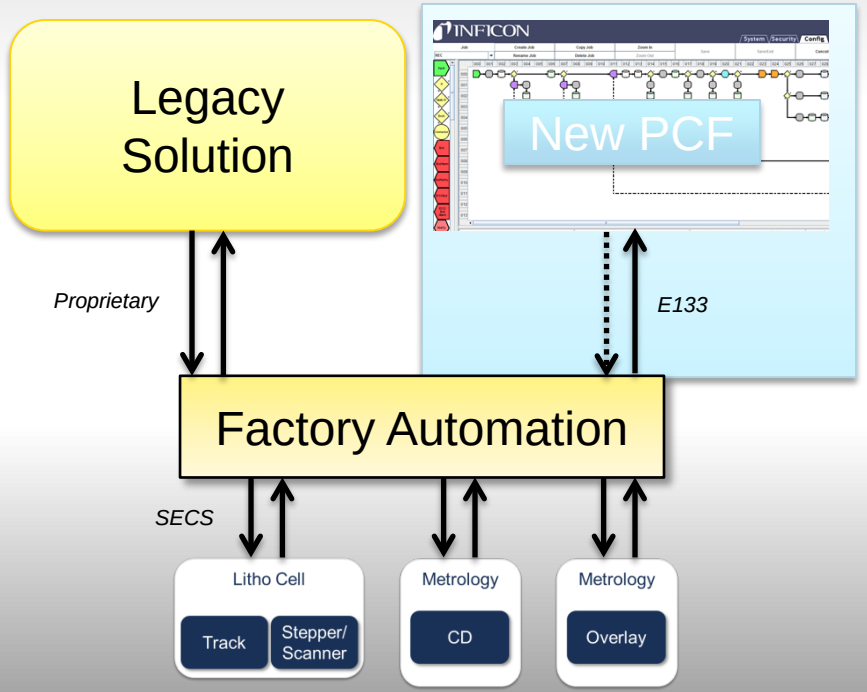
- INFICON is contracted to replicate the existing solution while demonstrating support and extensibility for future enhancements.
  - Success criteria based on matching POR control decisions, i.e. “apples to apples.”
  - Extract, transform, load and leverage existing controller configuration data.
  - 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.



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.



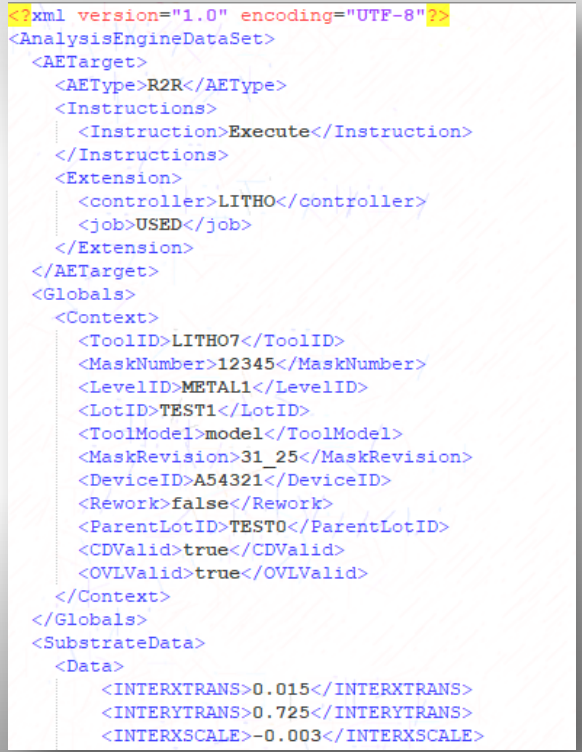
Integration

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.



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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

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, an 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

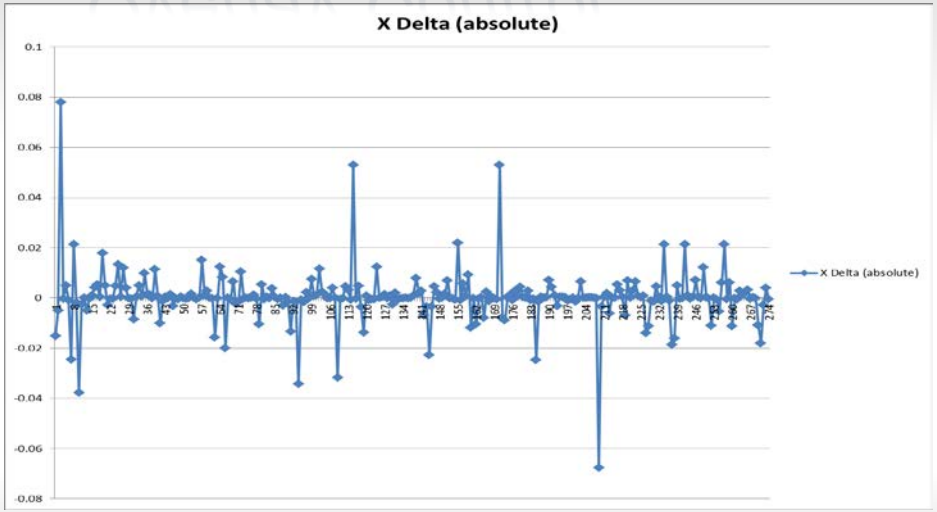
- Existing controller configuration data voluminous, cumbersome to replicate
  - Challenge with both the parameter data and the lookup methodology
  - Represented largest delays in project execution
  - Validation necessitated development of the standalone comparison tool
- State estimation used data 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.

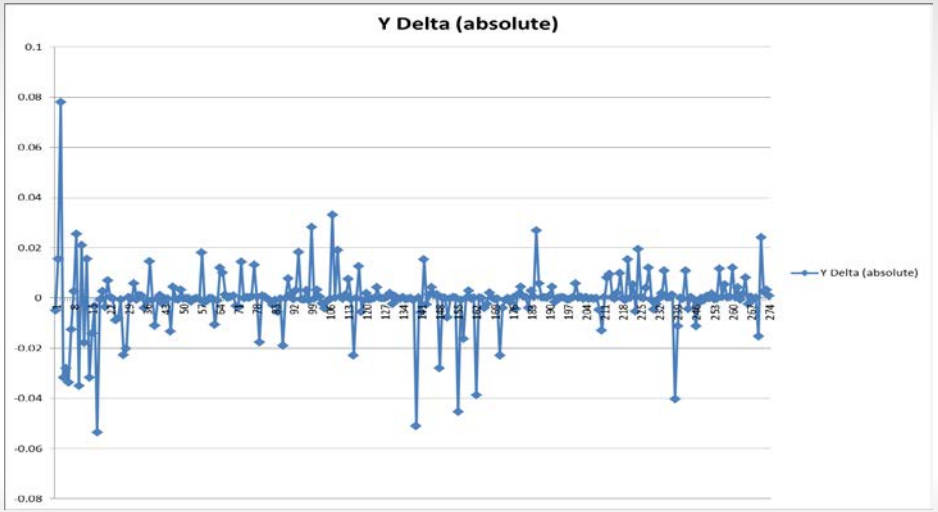
Validation
Exposure Control

- 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

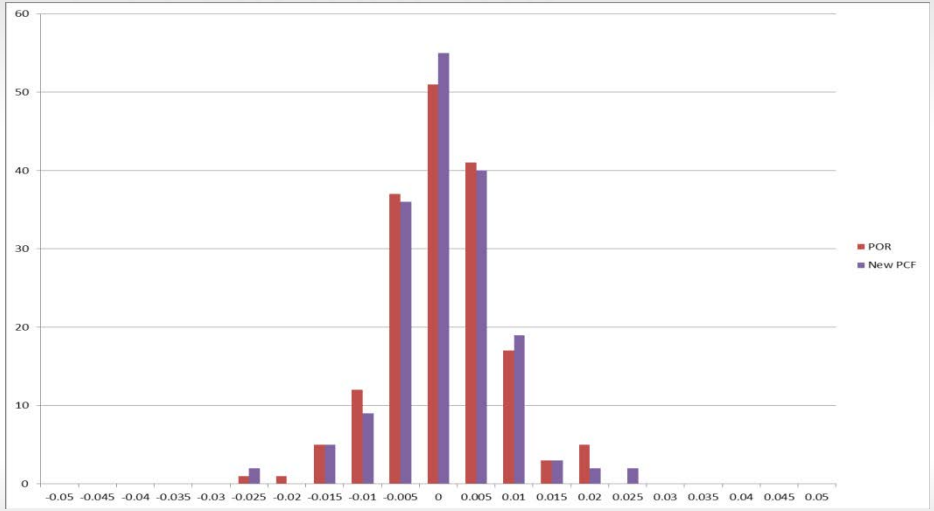


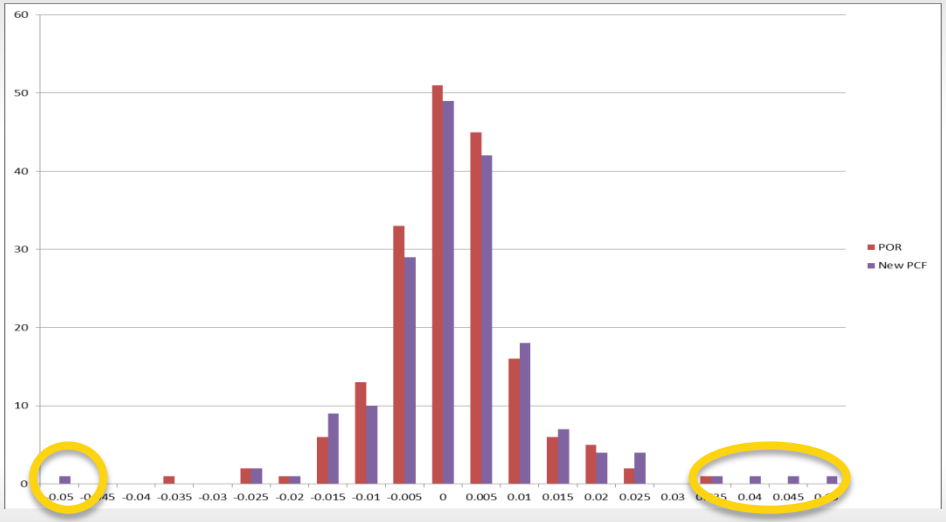


Overlay results were similar to those evident in the CD portion of the control strategy.

- 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!