Adaptive Metrology Solution for Aircraft FAL Automation
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An adaptive, flexible tool and a novel HMI enable rapid, accurate, deskilled laser tracker assisted aircraft joins

**Solution Overview**
An automated solution for a business jet Final Assembly Line (FAL), integrating metrology with kinematics to create a pseudo closed loop join processes run by custom HMI software communicating with laser trackers and PLC hardware, while providing operators with task-by-task instruction lists, requiring minimal instrument or program training.

**Features**
- Nearly closed loop deskills complex metrology operations
- Novel and universal HMI requires minimal operator training
- Highly customizable HMI workflows allow customer-driven join-process revisions
- Reduces build time through automated measurement and adjustment systems
- Supports multiple part variants through data package importation
- Increases join accuracy and precision through adaptive tooling

**Typical Working Cell Configuration**

**Total FAL System Elements**
- 3 Working Cells
- 3 HMI Computers
- 3 Seats Spatial Analyzer
- 3 Seats Custom HMI
- 8 Laser trackers
- 4 PLCs
- 28 Multi-axis positioners

**Adaptive Tooling Approach**
- Adapts to part-specific manufacturing differences
- Accepts data from component manufacturers to improve fits
- Enables in-process best-fits
- Minimizes alignment deviations at point of assembly
- Optimizes join for compensation to individual part variations
- Adjusts to fit multiple aircraft variants in one tool
  - Long range variant
  - Standard range variant

**Working Cell Configurations**

**Human Machine Interface Overview**
All working cell join processes are executed through the HMI software, running on each cell computer. Each working cell has a set of automated procedures called workflows stored on the computer, which are loaded one at a time, and walk the operator through every working cell operation requiring laser trackers and/or positioners. Each workflow is comprised of a list of tasks, each containing a title, user instructions, a graphic, and an automation command. For each task, the operator follows any instructions that require manual execution and the HMI executes any specified automation command such as measuring a group of points with a tracker or sending a transformation matrix to the working cell PLC, then proceeding to the next task until all tasks in the workflow have been completed.

**Features**
- Strong graphical interface decreases join process training requirements
- Minimalistic layout maintains user focus on operation objectives
- Step by step instructions preserve task linearity in join processes during part adjustment
- Workflows written in Microsoft Excel allow for easy join process revision by customer
- Interfaces with New River Kneumatic Spatial Analyzer for metrology functionality
- Supports communication with multiple instruments and PLCs over TCP/IP
- Automation commands deskill metrology operations with automatic troubleshooting
- Data set importation enables compensation for part-to-part deviations

**Workflow example**

**Achieved Join Accuracy**
Join process accuracies were measured and recorded during technology development by inserting undersized pins through alignment holes, imperfect alignment resulting in a smaller allowable pin size. For the wing-wing join, a mock-up wing with 4 pairs of alignment holes was used, to join accuracies of ±0.003" on the worst pair. For other joins types, similar accuracies were attained on the same order of magnitude.

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