Adaptive Metrology Solution for Aircraft FAL Automation

Robert Flynn and Schuyler Horky, Electroimpact Inc.

An adaptive, flexible tool and a novel HMI enable rapid, accurate, deskilled laser tracker assisted aircraft joins

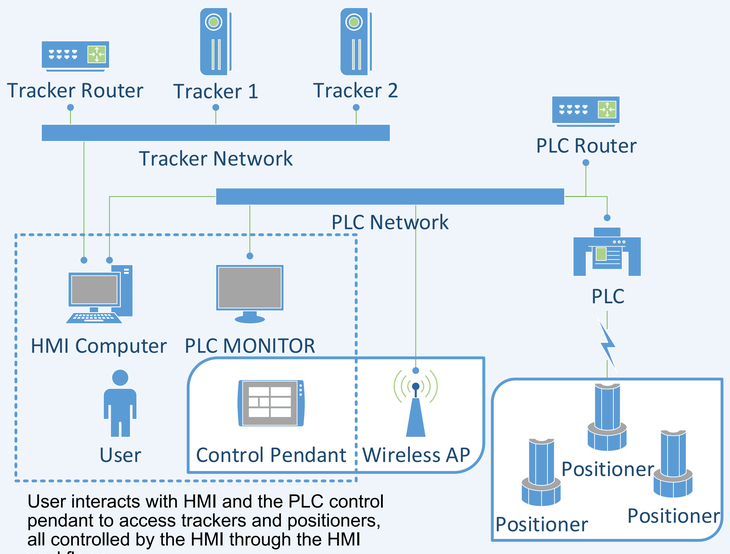
Solution Overview

An automated solution for a business jet Final Assembly Line (FAL), integrating metrology with kinematics to create 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 control 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



User interacts with HMI and the PLC control pendant to access trackers and positioners, all controlled by the HMI through the HMI workflows.

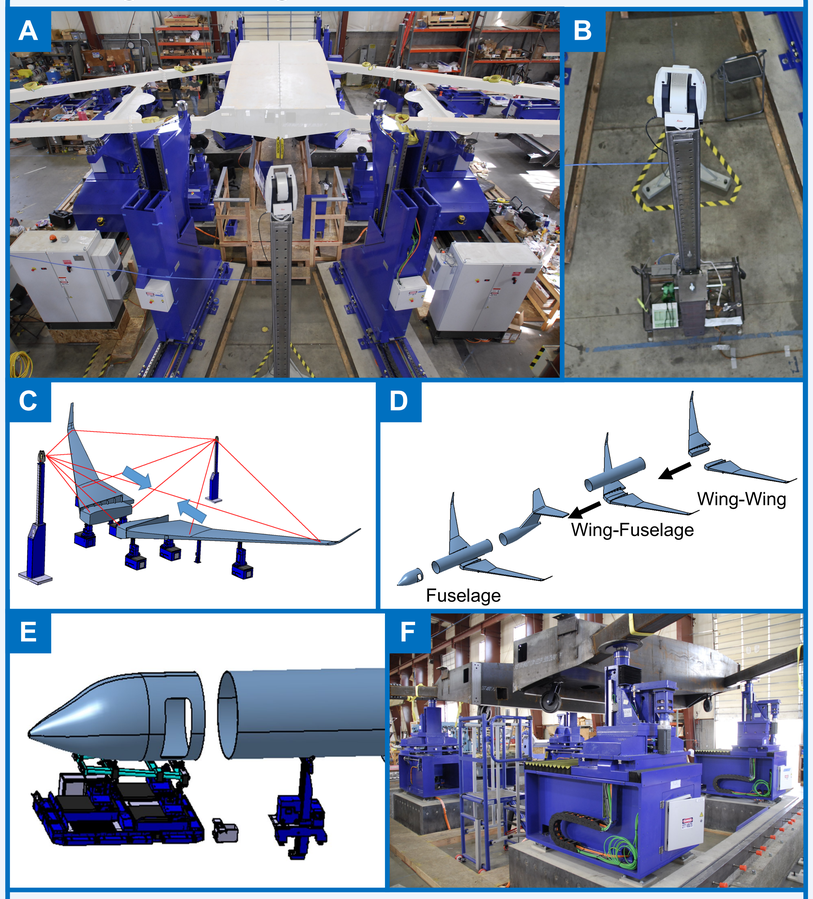
Total FAL System Elements

- 3 Working Cells
- 3 HMI Computers
- 3 Seats Spatial Analyzer
- 3 Seats Custom HMI
- 8 Laser trackers
- 4 PLCs
- Task-specific workflows
- 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



Figures

A. Joined mock-up wing used for functional testing
B. Pop-up tracker for the wing-wing join
C. Overview of the wing-wing join workcenter
D. FAL Join Process
E. Forward Fuse Join positioners
F. Positioners for the wing-wing join

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.

Acknowledgements

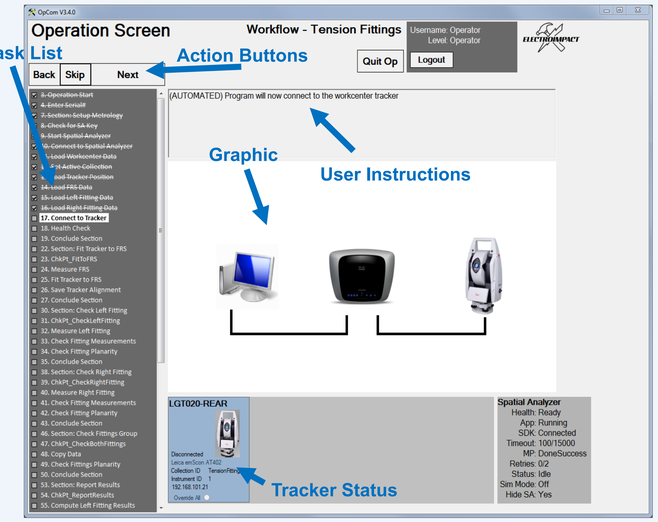
East Coast Metrology partnered with Electroimpact to create many of the workflows used in development

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 Kinematics’ 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



Screenshot of HMI connecting to tracker during an workflow

Workflow example

Task Title | User Instructions | Automation Command | Command Arguments

Task Title	Task Text	Task image filename	Method call	Arg_1	Arg_2	Arg_3	Arg_4
Section: Setup Metrol-	In this section, the track-	New Section.png	DisplayOperatorTask	none	none	none	none
Check for SA Key	Prog. will check for a	USB Drive.png	CheckDongle	none	none	none	none
Start Spatial Analyzer	Prog. will start the Spa-	Spa-	StartSA	none	none	none	none
Connect to Spatial Ana-	Prog. will now connec to	Spa-	ConnectToSA	none	none	none	none
Load Workcenter Data	Prog. will now load work-	Ope SAFile.png	OpenSAFile	TestBedTension-	none	none	none
Set Active Collection	Prog. will now select the	none	SetCollection	none	none	none	none
Load Tracker Position	Prog. will now load track-	Oper PointsFile.png	SetInstrumentTrans-	LGT020-REAR_Pos	WORLD	none	none
Load FRS Data	Prog. will now load foun-	Oper PointsFile.png	ImportFromCSV	FRS_Nominals.txt	Inches	Point-	none
Load Left Fitting Data	Prog. will now load left	Oper PointsFile.png	ImportFromCSV	Ten-	Inches	Point-	none
Load Right Fitting Data	Prog. will now load right	Oper PointsFile.png	ImportFromCSV	Ten-	Inches	Point-	none
Connect to Tracker	Prog. will now connect	ConnectToTrack-	ConnectInstrument	LGT020-REAR	FALSE	Leica	FALSE
Health Check	Prog. will now invoke	none	CheckBackSights	L5071	5.16	none	none
...	...	...	...	...	...	...	...

Image Filename

For more information, contact Rob Flynn RobF@electroimpact.com