



Evolving Automation Using SpatialAnalyzer

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OUTLINE

- Varying Degrees of Automation
 - SA Functions
 - MP/Scripts
 - Operator Assisted Process
 - Fully Automated Process

- Examples
 - Relationships for LLNL-NIF
 - MPs for Data Management - NIST
 - Tool Recertification on A350
 - Fuselage Assembly on Global 7000



Varying Degrees of Automation

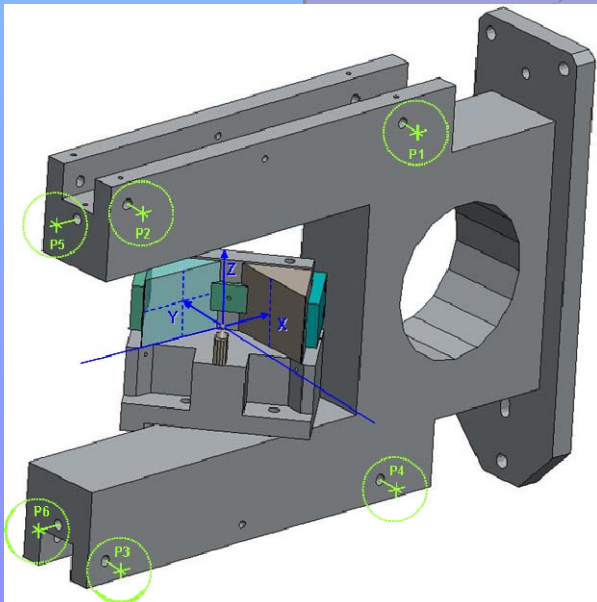
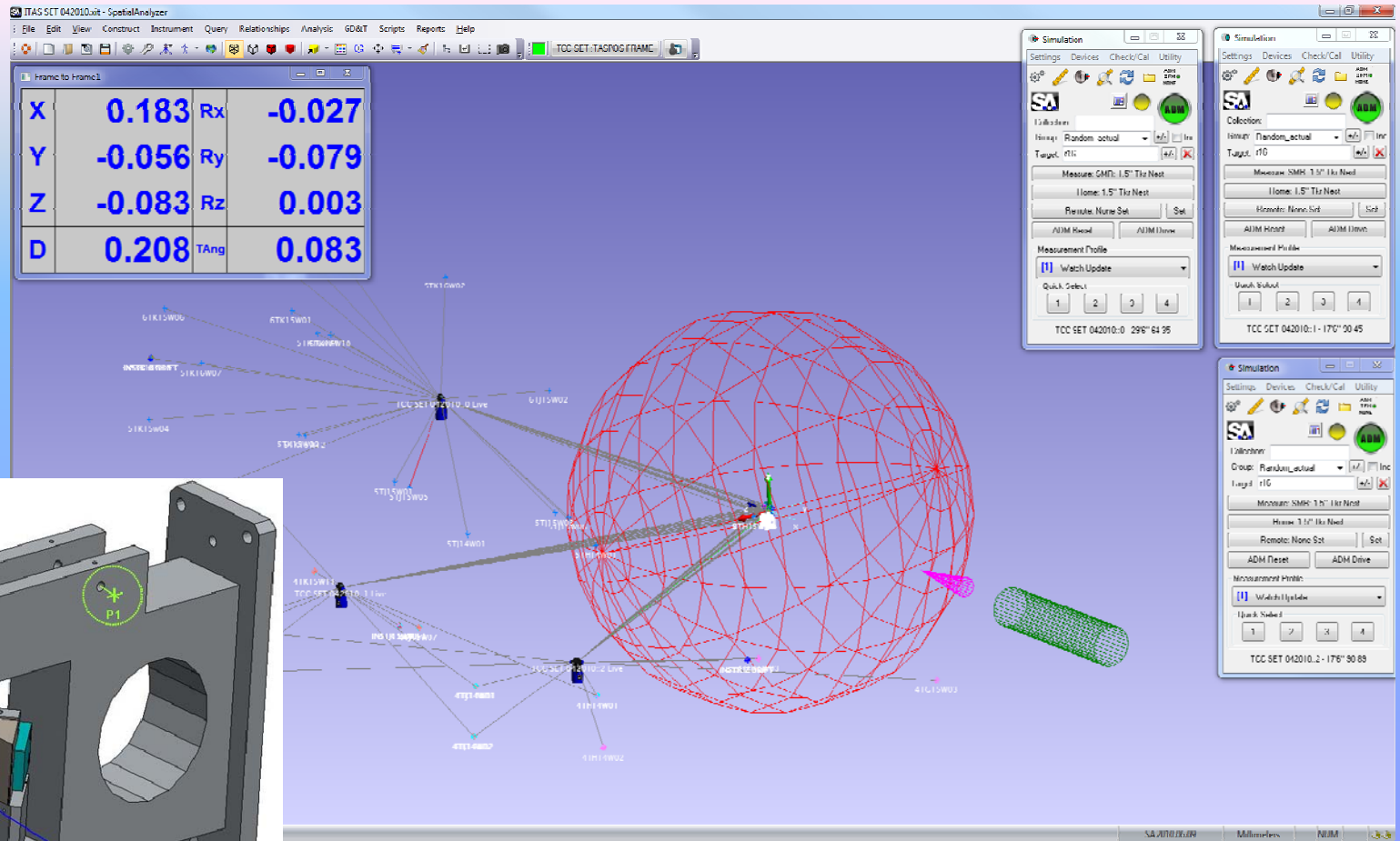
- Simplest – SA Functionality (i.e. Relationships)
- MP/Scripts – Set of programmable steps/settings
- Operator Assisted – User Interface or SA with prompts
- Fully Automated – User Interface with SA in background running without operator required



Simple Automation

- SA has ample functions for automating various measurement tasks:
 - Auto Measuring
 - Relationships
 - Pipe Fit Module
 - Auto Reporting
 - 6 DOF Trans-Track
 - Machine Calibration

Frame to Frame Relationship





Pipe Fit Module - Relationships

The screenshot displays the Pipe Fit Module software interface. The main window shows a 3D visualization of pipe relationships with various colored cylinders and lines. The left sidebar contains a tree view with categories like 'Instruments', 'Point Groups', 'Frames', 'Lines', 'Cylinders', 'Vector Groups', 'Relationships', and 'SA Reports'. Below the 3D view, there are several panels:

- Move Collections to Minimize Relationships:** A table with columns for Collection (check-moving), dX, dY, dZ, Rx, Ry, and Rz. It lists 'STOOL 2' and 'RSG 2'.
- Weight (c): Relationship:** A list of relationships with checkboxes and weights, including 'UT_W_S01' and 'PASS THRU OSG2'.
- Iteration 12, Eval 11, Objective = 144.570042:** A progress bar and status window showing optimization progress.
- Equations: 70, Max Obj: 513.1294, RMS Obj: 130.3740:** Summary statistics for the optimization process.

Buttons at the bottom include 'Run Optimization', 'Run Direct Search Optimization', 'OK - Accept transformations', and 'Cancel - Restore original transformations'.





Automation using Measurement Plans/Scripts

- Increasing level of control of automation
- SA User defines the steps and controls the level of complexity
- MP is tailored to fit the application or process
- Operator interaction can be highly refined
- Data can be output to populate other files or to feed information into a auxiliary activity



Measurement Plans in SA

SA Relationship MP.xit - SpatialAnalyzer

File Edit View Construct Instrument Query Relationships Analysis GD&T Scripts Reports Help

SA TreeBar

- Point Groups
- Frames
- Planes
- Measurement Plans
 - Relationship
- Default Folder

Database Explorer

MP Bar

Status Inspection Step

0	Make a Collection Object Name Reference List- Runtime Sel
1	Get Number of Objects in Collection Object Name Ref List
2	Create Counter
3	Get i-th Object From Collection Object Name Ref List
4	Make Strings from a Collection Object Name
5	Concatenate Strings
6	Make a Collection Object Name - Runtime Select
7	Make Strings from a Collection Object Name
8	Concatenate Strings
9	Make Groups to Objects Relationship
10	Increment Counter
11	Integer Comparison
12	Exit Measurement Plan

Relationship

Select all groups for relationships (Enter when Done)

Relationship

0 - Make a Collection Object Name Reference List- Runtime Select

Step Type: Make a Collection Object Name Reference List- Runtime Select

<Select all relation

Arg	Type	Description	Method	Value
0	String	User Prompt	Enter Value	Select all groups for relationships
1	Object Type	Object Type	Pick	Any
2	Collection Object	Resultant Collection Object	Result Only	Result Only

1 - Get Number of Objects in Collection Object Name Ref List

Step Type: Get Number of Objects in Collection Object Name Ref List

<number in list>

Arg	Type	Description	Method	Value
0	Collection Object Name Ref List	Object Name List	Reference	Ref {S0 A2}
1	Integer	Total Count	Result Only	Result Only

2 - Create Counter

Step Type: Create Counter

Arg	Type	Description	Method	Value

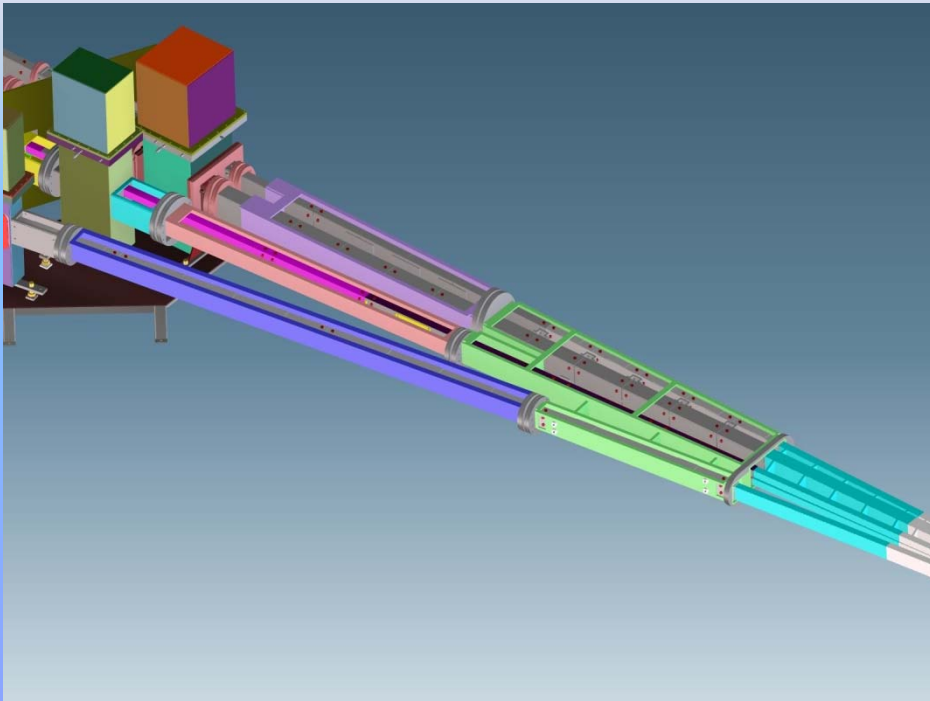
SA Ultimate - Engineered for Extreme Measures

SA 2014.06.17 (x64) Inches NUM

12:29 PM

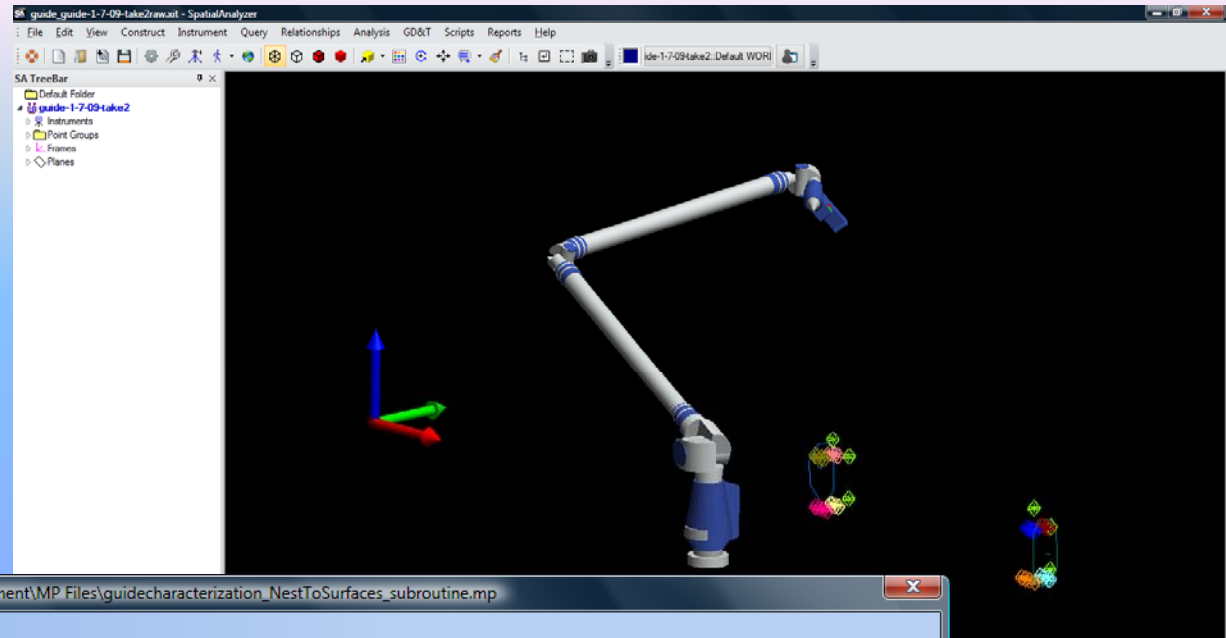


NIST – Neutron Guide Alignment





NRK SA with MPs for process automation



MP: C:\Users\Owner\Desktop\ECM\Projects\NIST\NIST Guide Alignment\MP Files\guidecharacterization_NestToSurfaces_subroutine.mp

File Step Password

Step List

- [0] Define Subroutine Input Values
- [1] Make a Point Name Ref List From a Group
- [2] Get Number of Point Names in Point Name Ref List
- [3] Set Integer Variable
- [4] Get i-th Point Name From Point Name Ref List
- [5] Make Strings from a Point Name
- [6] Get Point Coordinate
- [7] Construct Sphere
- [8] Make a String
- [9] Construct Surface From Sphere
- [10] Integer Math Operation
- [11] Set Integer Variable
- [12] Integer Comparison
- [13] Define Subroutine Return Values

Step Title: Define Subroutine Input Values
Comment:

Arguments

Arg	Type	Description

guidecharacterization_NestToSurfaces_subroutine.mp

0-Define Subroutine Input Values Step Type: Define Subroutine Input Values

Arg	Type	Description	Method	Value

1-Make a Point Name Ref List From a Group Step Type: Make a Point Name Ref List From a Group

Arg	Type	Description	Method	Value
0	Collection Object Name	Group Name	Enter Value	:::nests
1	Point Name Ref List	Resultant Point Name List	Result Only	Result Only

Taskbar: CMSC2011NIST.ppt..., CAUsers\Owner\De..., Guide System Install..., SA guide_guide-1-7-09...



Operator Instructed Task

Airbus A350 Wing Jig Inspection





A350 Rapid Tool Recertification

Task Definition for Automating Measurements

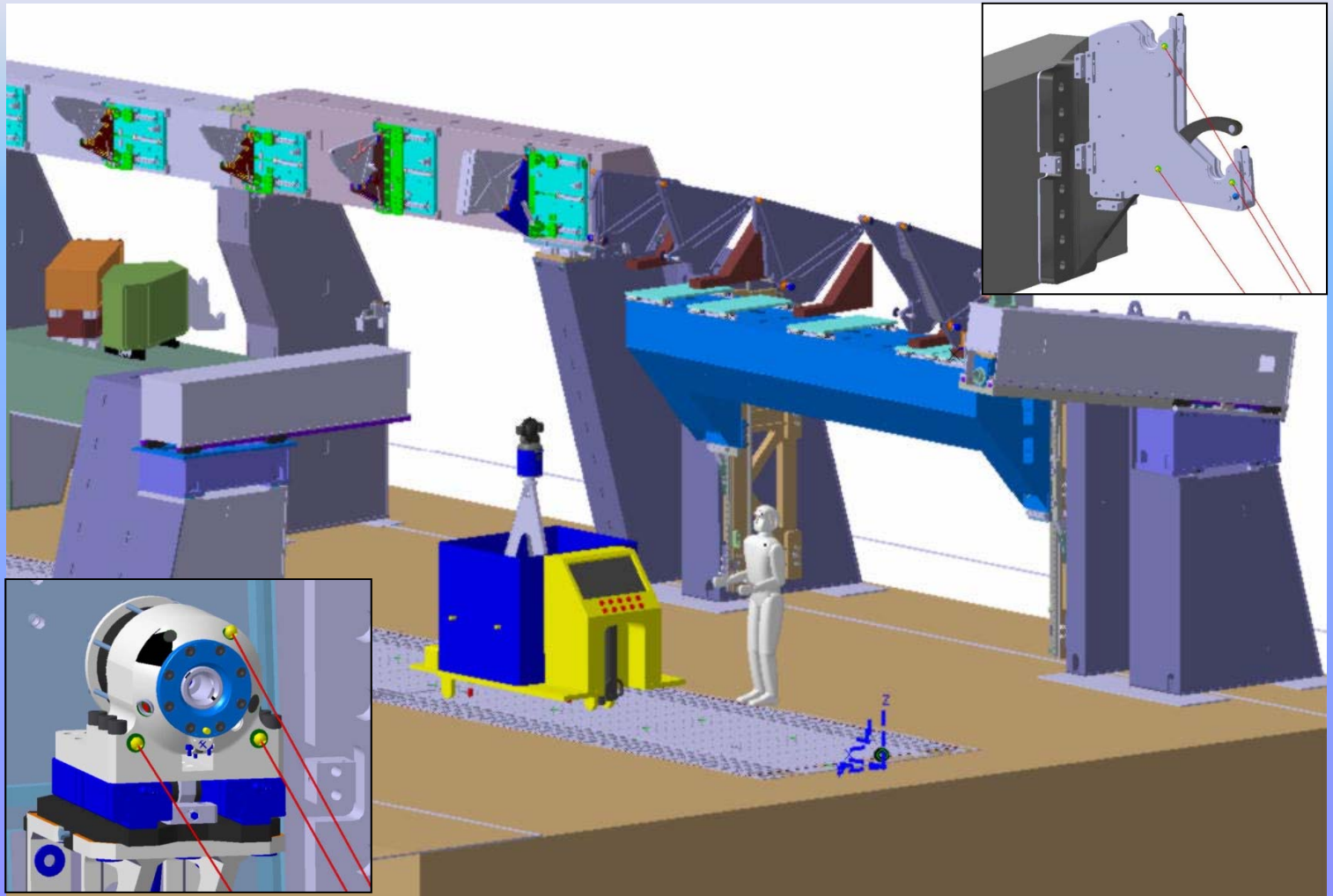
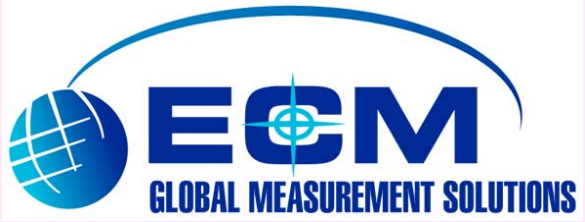
Automation

An essential element in the AUK request for a rapid tool recertification was to try and incorporate as much automation into the solution to reduce specialized skill requirements. Much of the recertification process can be automated even without achieving a completely automated or “push button” solution.

Steps that lend themselves to automation include:

- Scripted instructions to the operators through the PC console,
- Scripted analysis of the measurements,
- Scripted feedback to the operator and
- Database tracking of both jig status and interchangeable details.

The entire process of rapid tool recertification has the potential for complete automation in the future with the addition of a measurement instrument positioner such as an AGV or small robot.





Mini Test Jig for A350

KarlC-develop_2009-08-20 - Spatial Analyzer

File Edit View Construct Instrument Query Relationships Analysis Scripts Reports Help

NOMINAL:JIG

MEASUREMENTS:0

5 - Get Last Instrument Index

Arg	Type	Description	Method	Value
0	Integer	Instrument ID	Result Only	Result Only
1	Collection Instrument	Instrument ID	Result Only	Result Only

6 - Set Instrument Transform

Arg	Type	Description	Reference	Method	Value
0	Collection Instrument ID	Instrument to Move	Reference	Ref (SS AG)	
1	Transform	Destination Transform	Enter Values	Enter Value	5130.308000 -1519.802000 1110.000000 -0.227350 0.906230 -74.157020 A:World Frame
2	Collection Object Name	Reference Frame	Enter Value	Enter Value	A:World Frame
3	Integer	Number of Steps	Enter Value	Enter Value	10

7 - Import ASCII: Predefined Formats

Arg	Type	Description	Method	Value
0	File Path or Embedded File	ASCII File Path	Enter Path	C:\Documents and Settings\user\Desktop\MiniJig_NOM_SRL.txt
1	File Format	File Format	Pick	GroupName PointName X.Y.Z
2	Units	Units	Units	Millimeters
3	Collection Object Name	Group Name	Enter Value	...Point Group
4	Boolean	Import as Cloud	Enter Value	FALSE

8 - Auto-Scale

Arg	Type	Description	Method	Value
			Auto-Scale	

9 - Copy Object

Arg	Type	Description	Method	Value
0	Collection Object Name	Source Object	Enter Value	MinJig:AM
1	Collection Object Name	New Object Name	Enter Value	MinJig:AM Actuals
2	Boolean	Overwrite if exists?	Enter Value	TRUE

SpatialAnalyzer - Engineered for Extreme Measures.

SA 2009.07

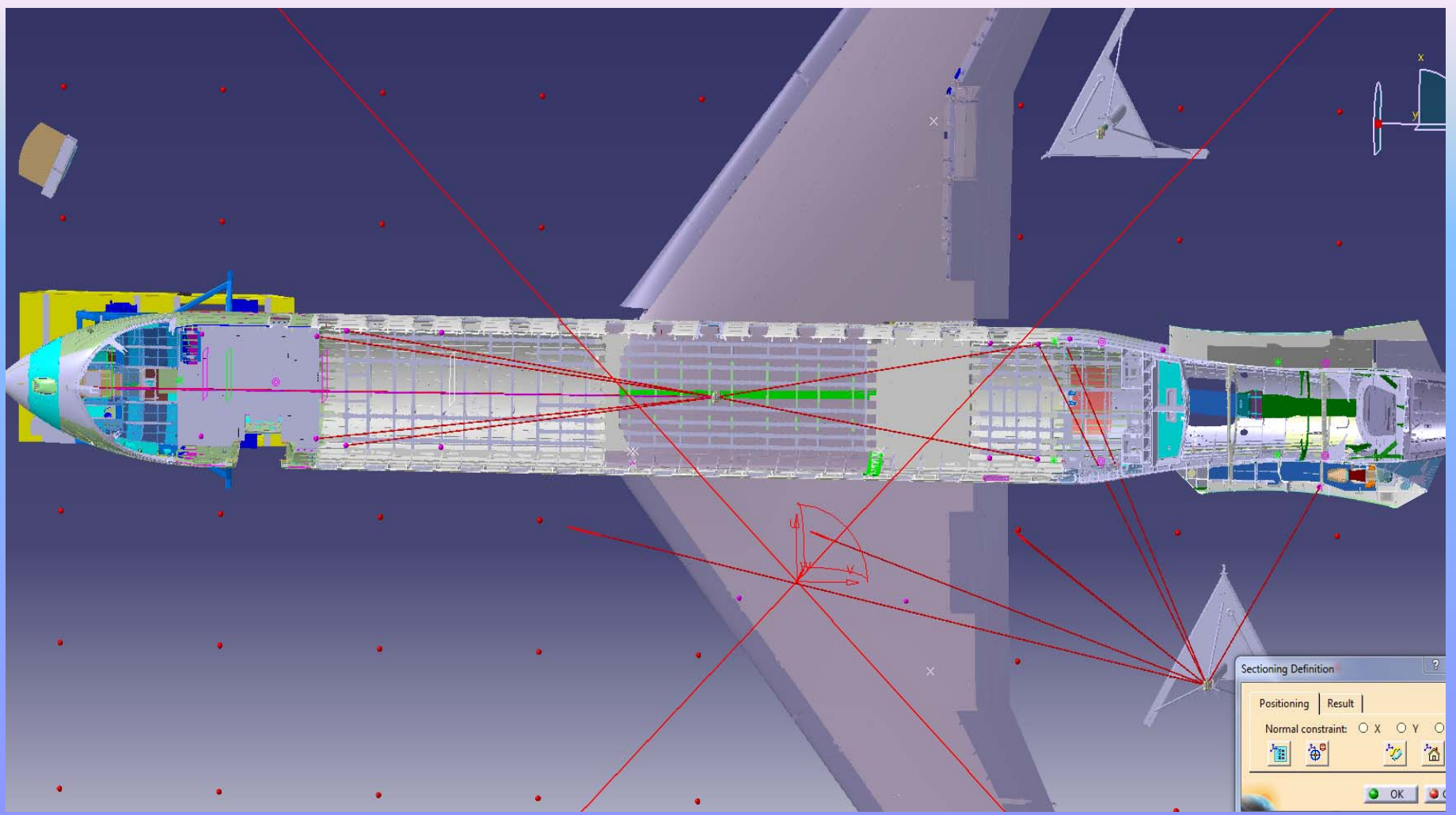


Fully Automated Aircraft Join

- Fuselage Assembly of Business Jet
 - Join Wings
 - Join Center Fuselage to Wings
 - Join Fwd / Aft to Center Section
 - Align Flight Control Surfaces
- Operation Must Not Require Metrologist
- User Interface Will Not Show SA Screens
- Joining and Measuring Tightly Integrated Between Siemens Controller and SA
- Reporting/Data Storage Automated



Forward/Aft Fuselage Join





Join Station with Controllers





Test Join AC #001



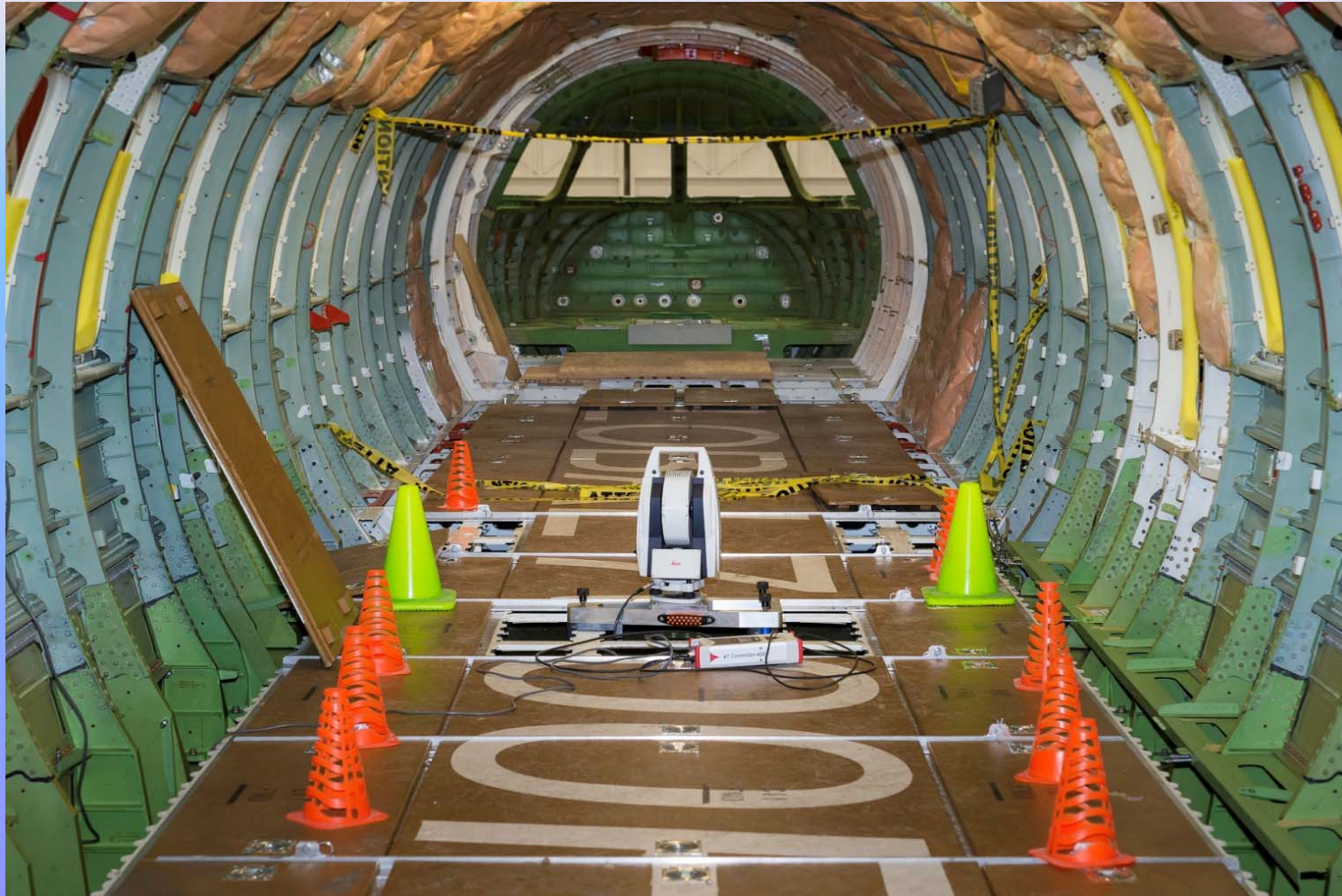


Automated Workstation





Global 7000 Interior During Join





Final Thoughts on Automation

- Automation can be as simple as defining a relationship or using an existing function
- The flexibility of SA allows users to begin with existing functions and mature to develop highly efficient and capable MPs or coded programs
- The level of automation is dictated by the necessity to repeat a process and the skill of the operators performing the tasks
- Many of the tasks initially attempted using some of SA's built in functions can be upgraded to either partially or fully automated measurements and alignment activities.