

# Recent Developments in the Harmonization of ISO 10303 STEP and ASME Y14.37 Composite Material Standards

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## GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023



- **35 years experience in the Aerospace industry**
  - GD/FW-Lockheed-Lockheed Martin
  - Developed and applied composite material structural analysis, design, and design synthesis tools for military aircraft
  - F-111, F-16, F-16XL, ATF/YF-22, F-22, various Skunk Works projects
  - Retired from Skunk Works end of 2013
- **Participated in the ISO 10303-STEP standard since 1987**
  - Initially focused on Engineering Analysis
  - Convener of WG12 since early 2000's
  - Initially led the Integrated Resources development
  - Now responsible for overall 10303 STEP development (WG12) and maintenance (WG21)
- **Led the PDES Application Protocols for Composites (PAS-C) AP209 effort**
  - Focused on Engineering Analysis of composite structures
- **Since retirement have consulted on updating the composites aspects of 10303 and running ISO TC184 SC4/WG12 and WG21 (STEP standardization and support)**

# Overview of Presentation

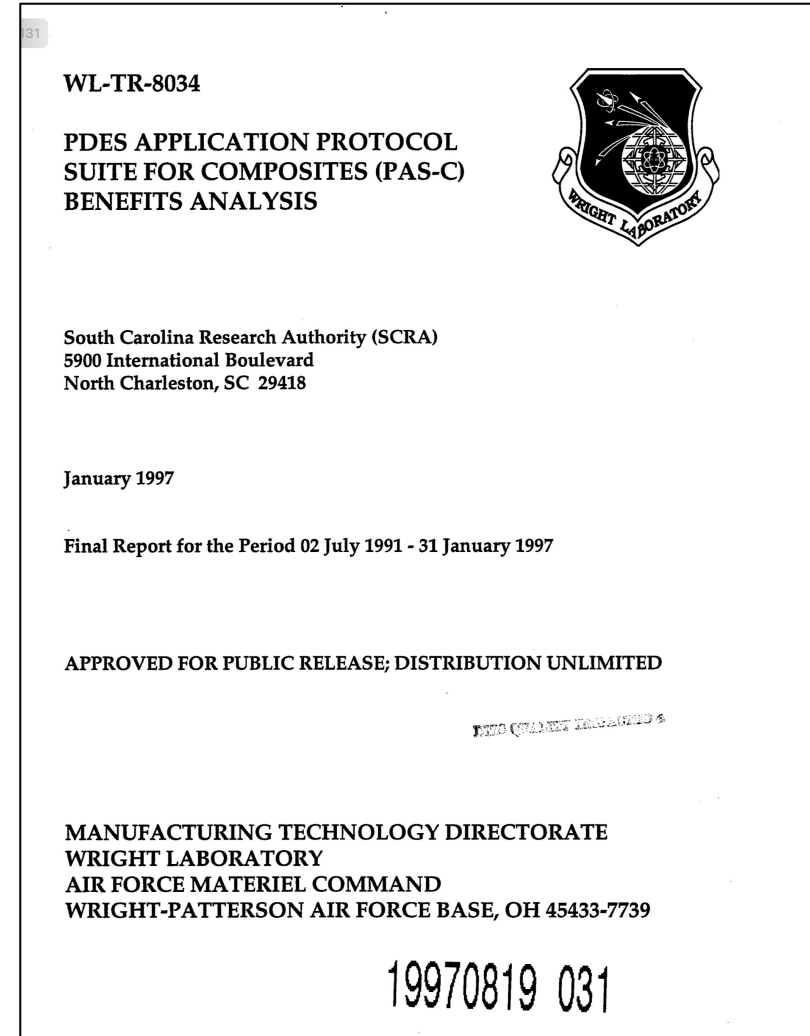
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- **History of the 10303 STEP composite material standardization development in the PAS-C program**
- **Initial harmonization efforts between ISO 10303 and ASME Y14.37 standards and LOTAR/CAX-IF testing uncovered the need for:**
  - **Additional Rosette types, and ply/part boundary and shape representations**
  - **Recommended practices development and update**
- **Further joint LOTAR/ISO/ASME composite team specification and implementation of 10303 Limited Length or Area Indicator (LLAI) capabilities**
- **Future work on propagating 10303 composites capabilities from 10303-242 Mechanical Design and PLM to 10303-238 Manufacturing**

# History of the 10303 STEP composite material standardization development in the PAS-C program

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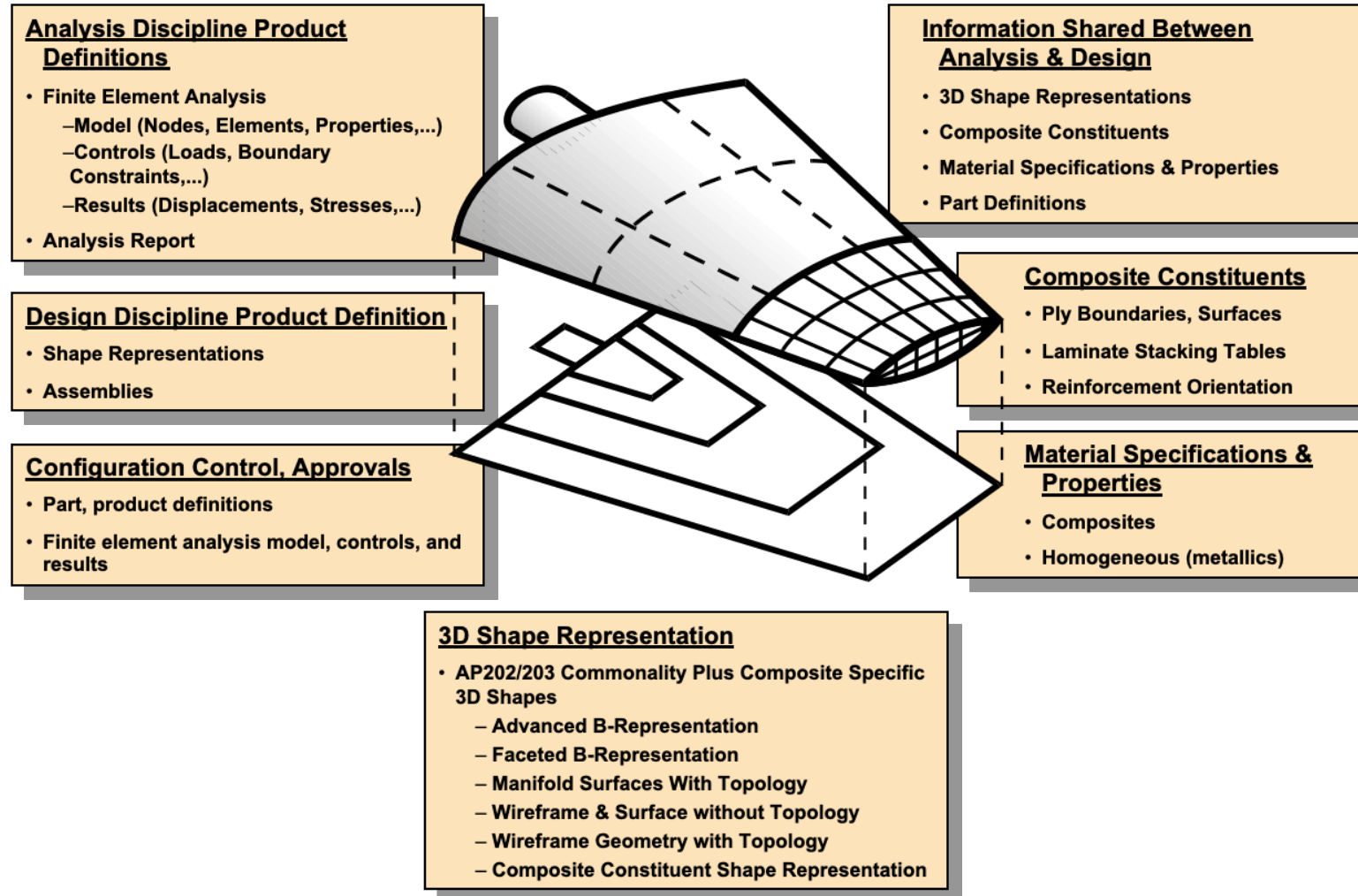
- **PDES Application Suite for Composites (PAS-C) started in 1991**
  - Initially funded by Manufacturing Technology Directorate at the Air Force Research Laboratory
  - Initial aim was supporting B-2 and F-22
- **PAS-C focused on reducing the cost of composite aircraft components through the use of concurrent engineering practices enabled by standardized product information**
- **Three Application Protocols were envisioned:**
  - AP209 for Engineering Analysis, Composites
  - AP222 for Manufacturing (uncompleted)
  - AP232 for Technical Data Package



# 10303-209 (AP209) Focused on Engineering Analysis and Composite Product Definitions

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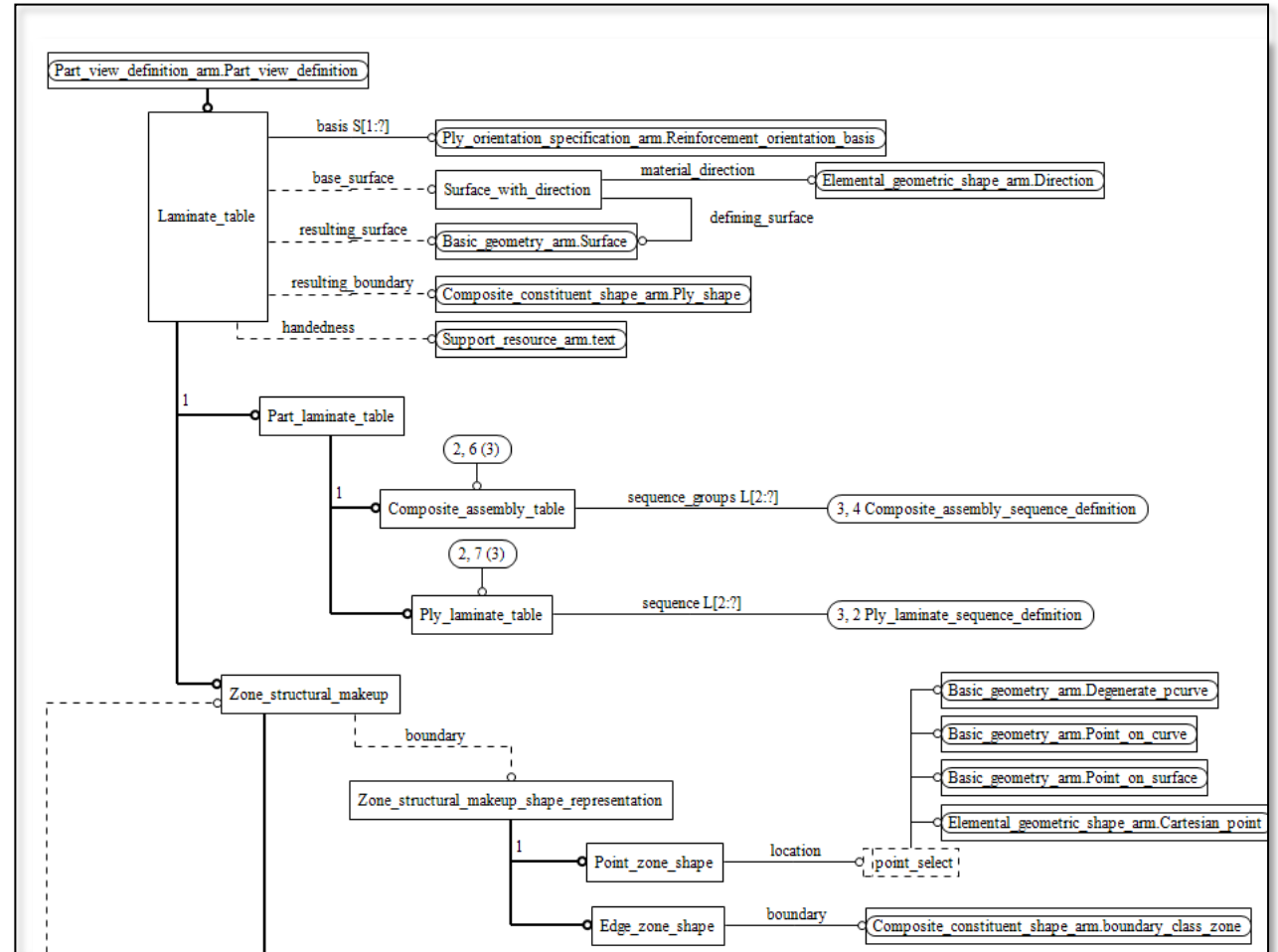
- Added the Engineering Analysis product definition information to that of AP203 (Later AP242)
- Traditional 2D composite constituents, laminate tables and materials
- A full 3D representation of composite laminations (plies) was a first
- Initial Draft International Standard (DIS) in 1996, final International Standard (IS) in 2000



# The Core Information Model for Composite Product Data is Now Shared across the 10303 STEP Standard

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- The ISO 10303 Laminate Table is broken down into three major Subtypes
  - A Composite assembly table comprised of traditional 3D shape representations that may be non-laminated parts combined with 2D/3D laminated composites
  - A Ply Laminate Table for traditional ply-based composite parts
  - A Zone Structural Makeup for either design-oriented part specifications or specialized analysis-oriented specifications



# Initial harmonization efforts between ISO 10303 and ASME Y14.37 standards and LOTAR/CAX-IF testing uncovered several needs

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- **Additional Rosette types, and ply/part boundary and shape representations were added**
  - Additions reflect design and manufacturing practices that had evolved since the initial 10303 publication in 2000
- **Recommended practices for implementors were updated to reflect the new additions**
  - Based upon input from CAX-IF testing and Dassault implementations
  - Provides detailed instantiation recommendations



**CAX-IF Recommended Practices**  
for  
**Composite Materials**

Version 4.2, August 17, 2021  
Status: Final

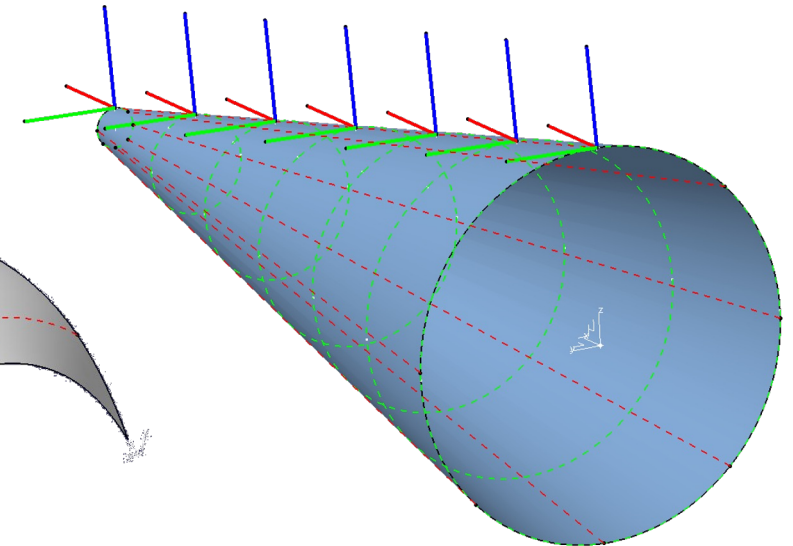
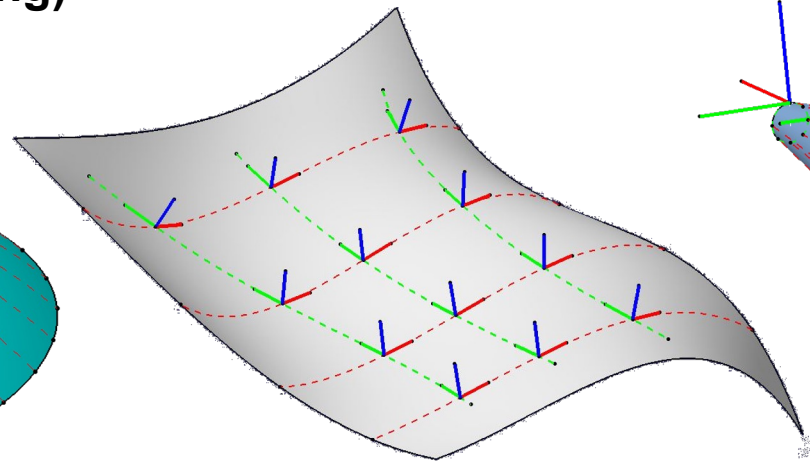
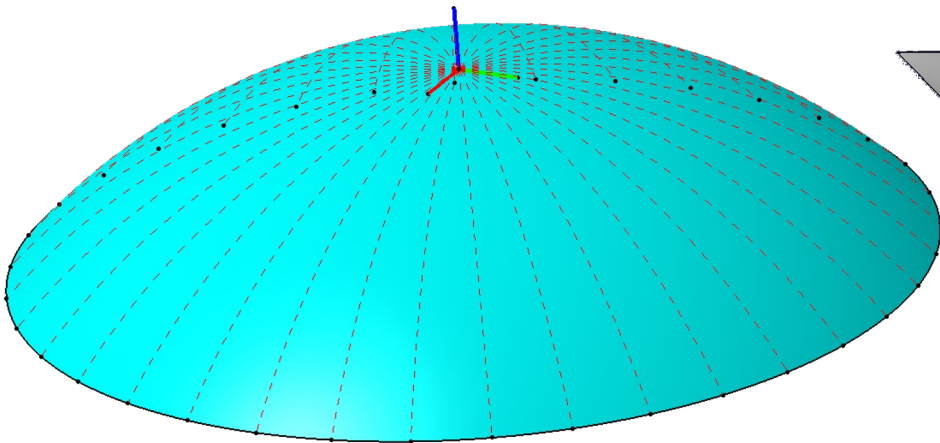
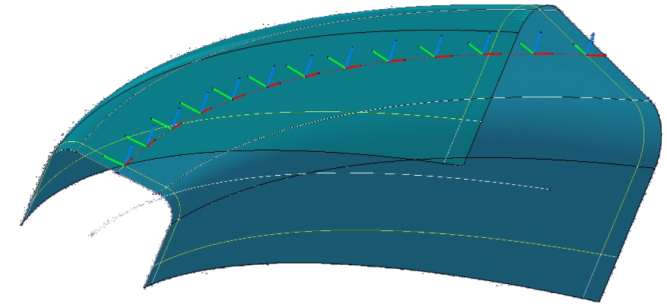
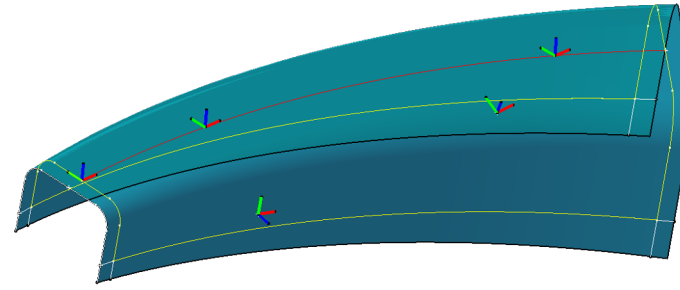
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# New Rosette Types Added to Reflect Recent Design and Manufacturing Practices

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- **ASME Y14.37 and user input formed the basis for the new Rosette types**
  - Rosettes are coordinate frames used to orient the fibers in a ply
  - A Cartesian coordinate frame is always used as the origin direction specification for a Laminate Table basis (tooling) surface

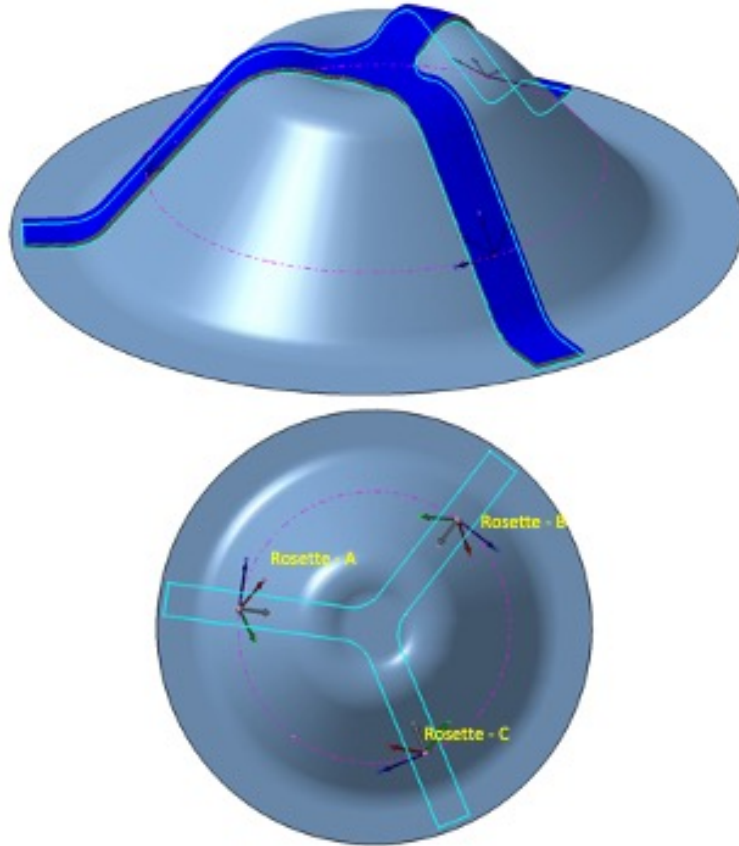




# Multiple Rosettes were Added to Reflect Very Complex Curved Part Specification Requirements

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## Example: Multiple Rosettes for a Laminate Table



Sequence	Part Number	Piles Group	Sequence	Ply/Core	Material ID	Orientation Name	Rosette
1	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.1	PLY.P1	30721	0	Rosette - A
	Example	ASSEMBLY					
2	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.2	PLY.P2	30721	45	Rosette - A
	Example	ASSEMBLY					
3	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.3	PLY.P3	30721	-45	Rosette - A
	Example	ASSEMBLY					
4	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.4	PLY.P4	30721	90	Rosette - A
	Example	ASSEMBLY					
5	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.5	PLY.P5	30721	0	Rosette - B
	Example	ASSEMBLY					
6	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.6	PLY.P6	30721	45	Rosette - B
	Example	ASSEMBLY					
7	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.7	PLY.P7	30721	-45	Rosette - B
	Example	ASSEMBLY					
8	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.8	PLY.P8	30721	90	Rosette - B
	Example	ASSEMBLY					
9	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.9	PLY.P9	30721	0	Rosette - C
	Example	ASSEMBLY					
10	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.10	PLY.P10	30721	45	Rosette - C
	Example	ASSEMBLY					
11	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.11	PLY.P11	30721	-45	Rosette - C
	Example	ASSEMBLY					
12	ASME Y14.37	PLY GROUP -1					
	3-Blade	BOND	PLY-LEVEL.12	PLY.P12	30721	90	Rosette - C
	Example	ASSEMBLY					

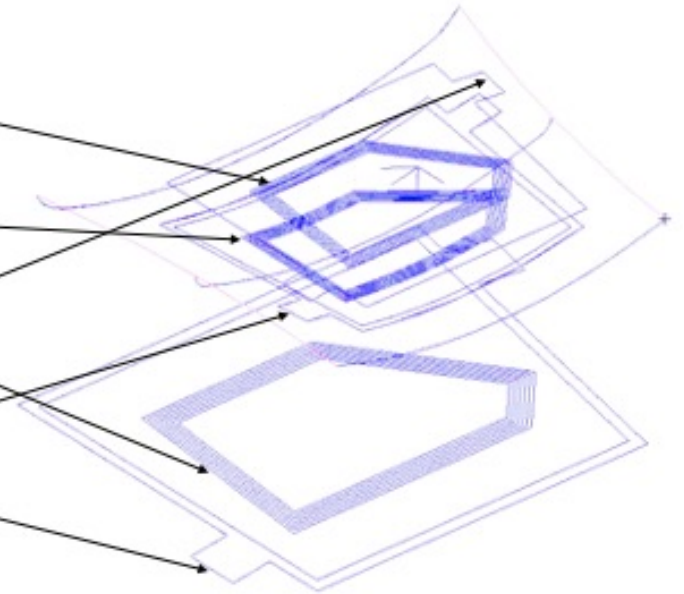
# New Ply Shape Definitions Address the Needs of Both Design and Manufacturing

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- **The new Ply Shape definitions enable the sharing of a common Laminate Table for process integration**
- **Design edge of Ply/Part for the nominal as-designed representations**
- **Manufacturing edge of Ply/Part for as-manufactured representations**
  - Typical need addressed is representing excess material providing areas for tooling and material application excess

## Edge of Ply Options Example

- projected ply shape
  - surface ply shape
  - view ply shape
- laid ply shape
- flat pattern ply shape
- manufacturing projected ply shape
  - manufacturing surface ply shape
  - manufacturing view ply shape
- manufacturing laid ply shape
- manufacturing flat pattern ply shape



# Further Joint LOTAR/ISO/ASME Composite Team Efforts Focused on the Specification and implementation of 10303 Limited Length or Area Indicator (LLAI) Capabilities

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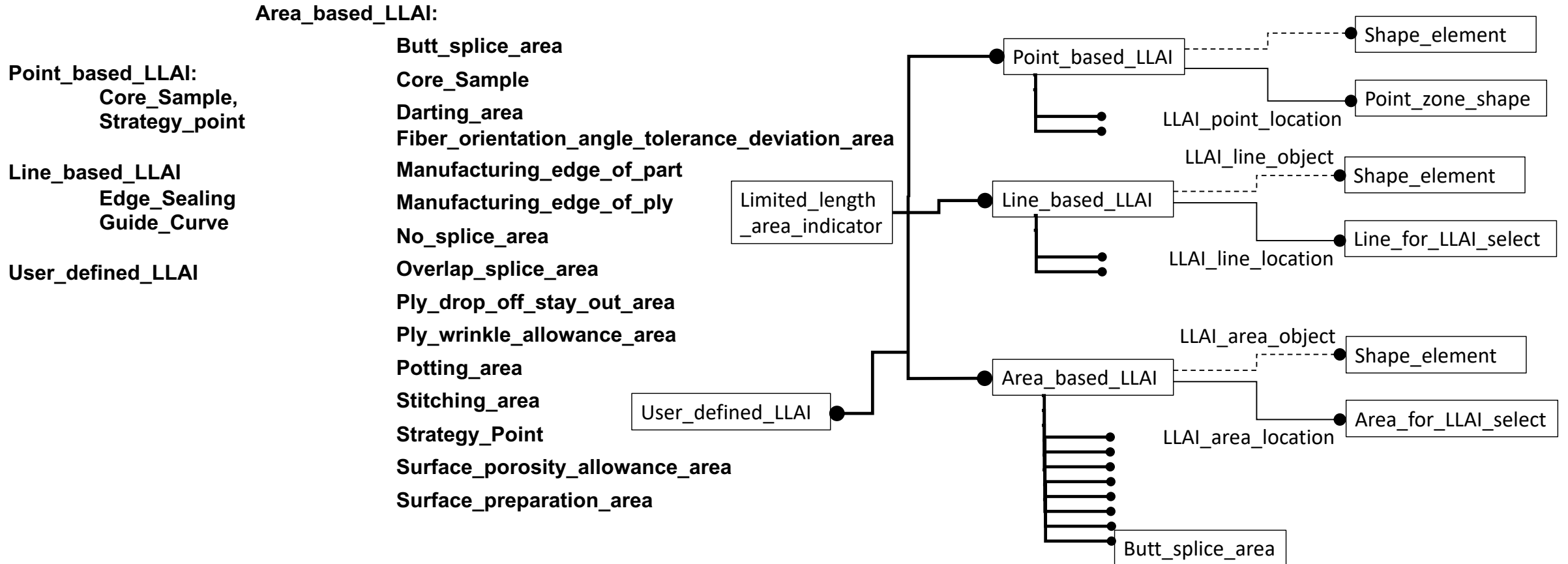
- **A Limited Length or Area Indicator (LLAI) is an intelligent note that adds definition to to composite laminate tables, and constituents such as shapes, points, lines and areas**
- **Joint Composites team started with the ASME Y14.37 LLAI specification**
  - **Several spreadsheets created to document LLAI candidates and their definitions**
  - **A few 10303 objects were added along with some from member companies and vendors**
- **New 10303 module to be balloted this fall**
  - **To be published with AP242 ed4**

ASME Y14.37 LLAI Type	Identifier	Type details	Geometric Representation(s)	Requirements	ISO 10303 Applicable Entity(s)
Overlap Splice Area	String	Overlap direction, overlap width, stagger distance between plies, number of plies between repeated splice locations	Part shape, Area, Drection, Length	Process document, Note, GD&T	Part, Ply table, Ply
Butt Splice Area	String	Minimum gap, maximum gap, stagger between splices, number of plies between repeated splice locations	Area, Length	Process document, Note, GD&T	Ply table

Domain	Abstract	Priority	Comments	AP242 Edition	CAX-IF UG (PDES Redmine)	Jira Working Item
Composites	Support for Flat Patterns	P0	Needs update to RP and interop testing.	E1	Feature 43: Composite Ply shape User Story: 45	TCSC410303-401 Update Flat-pattern ply shape
Composites	Support for EOPs	P0	Needs update to RP and interop testing.	E2	Feature 43: Composite Ply shape User Story: 44	TCSC410303-651 Manufacturing Edge of Ply TCSC410303-652 Manufacturing Edge of Part
Composites	Support for LLAI - Additional Geometries and UDA	P0	On Hold For CAX-IF RP Development and Test. Need an addendum in the Recommended Practices to allow having supplemental geometry/params in Composite STEP entities/structure.	ED1/ED2	Capability 6: Composite Feature: 113 (LLAI) User Story: 152 (additional geometry UDA)	TCSC410303-650 User Defined
Composites	Support for Seed Points (Producibility Params)	P1	On Hold For CAX-IF RP Development and Test. Need an addendum in the Recommended Practices to allow having supplemental geometry/params in Composite STEP entities/structure.  Should follow similar RP as for UDA's in Geometric Sets?	ED1/ED2	Capability 6: Composite Feature: 113 (LLAI) User Story: 111 (strategy point, course start point)  Also: Feature #115: Producibility parameters	TCSC410303-646 Strategy Point
Composites	Support for Start Points	P1	On Hold For CAX-IF RP Development and Test. Need an addendum in the Recommended Practices to allow having supplemental geometry/params in Composite STEP entities/structure.	ED1/ED2	Capability 6: Composite Feature: 113 (LLAI) User Story: 111 (strategy point, course start point)	TCSC410303-646 Strategy Point

# LLAI Types are Grouped by Geometric Association

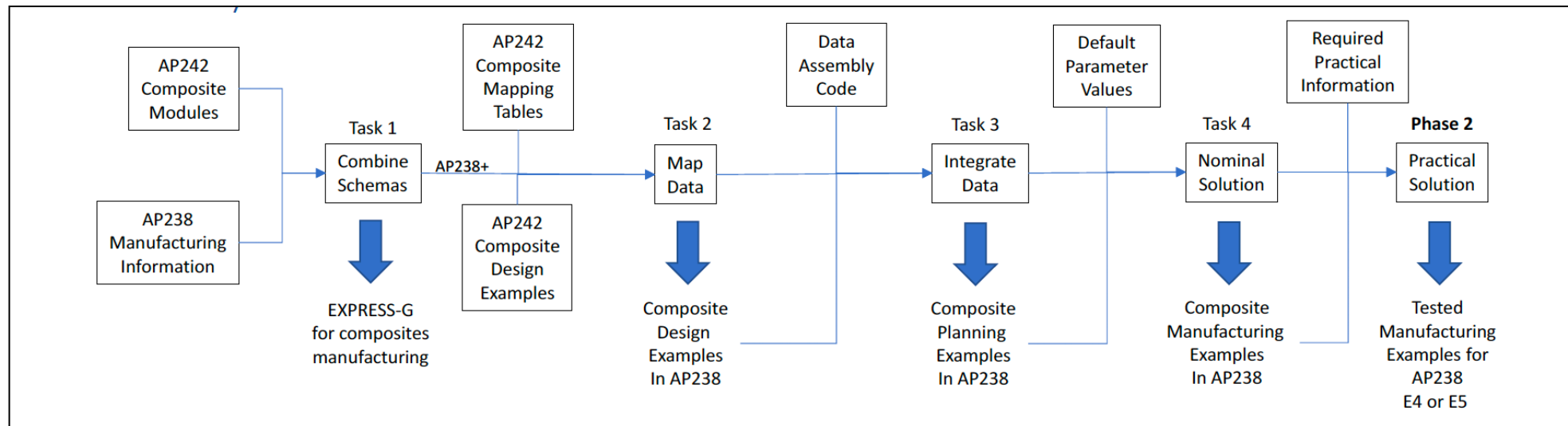
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# Future work on propagating 10303 composites capabilities from 10303-242 Mechanical Design and PLM to 10303-238 Manufacturing

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- **Future work will center around three areas**
  - **Composite constituent shape representations for manufacturing such as strips, courses, sectors**
  - **Rosette extensions such as guide curve start points, and multiple guide curves**
  - **AP242 (Mechanical design) and AP238 (Manufacturing) Integration**



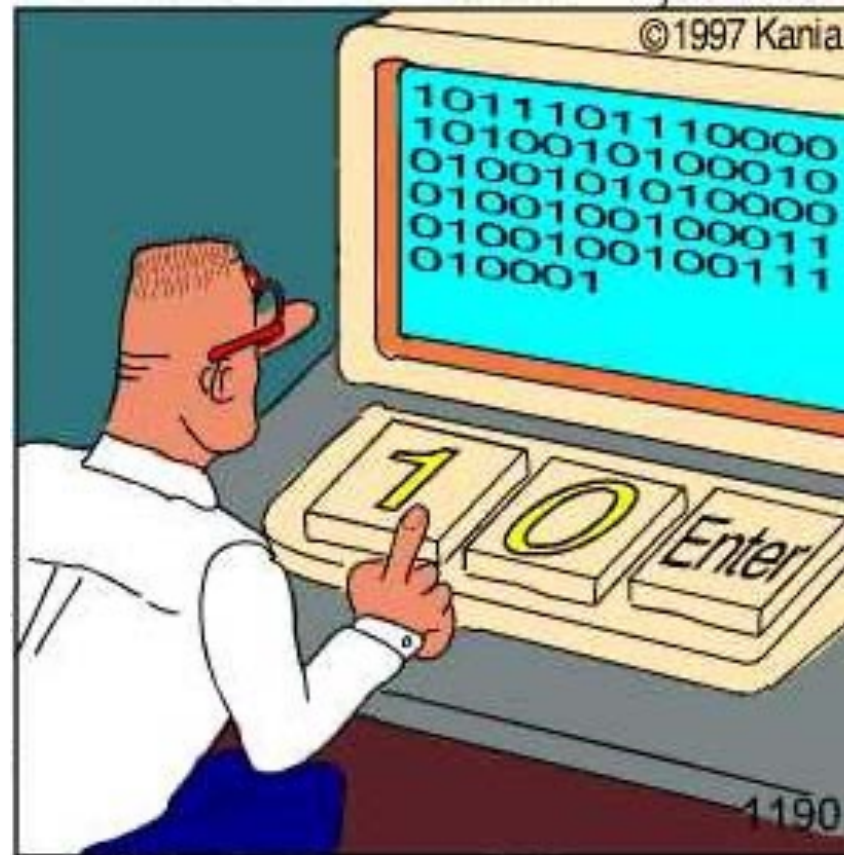
# Credit for Contributions to These Efforts is Due to Many!

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- **Contributing People, Groups, and Organizations include (but not limited to!):**
  - **United States Air Force Research Laboratory (AFRL)**
  - **US National Institute of Standards and Technology (NIST)**
  - **South Carolina Research Authority (SCRA)**
  - **CAX-IF, NAFEMS, PDES, Inc., ProSTEP**
  - **Airbus, Boeing, BAE Systems, General Dynamics, Liberty Business Associates, Lockheed Martin, McDonnell Douglas, Northrop Grumman, PDIT, Saab Scania, Vought**
  - **AIAA, ANSI, ASME, ISO, PDES**
- **And many others that I cannot remember over the last 30+ years...**

# Questions?

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Real programmers code in binary.