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Computer Aided Process Planning for
Automated Fiber Placement





Computer Aided Process Planning for Automated Fiber Placement

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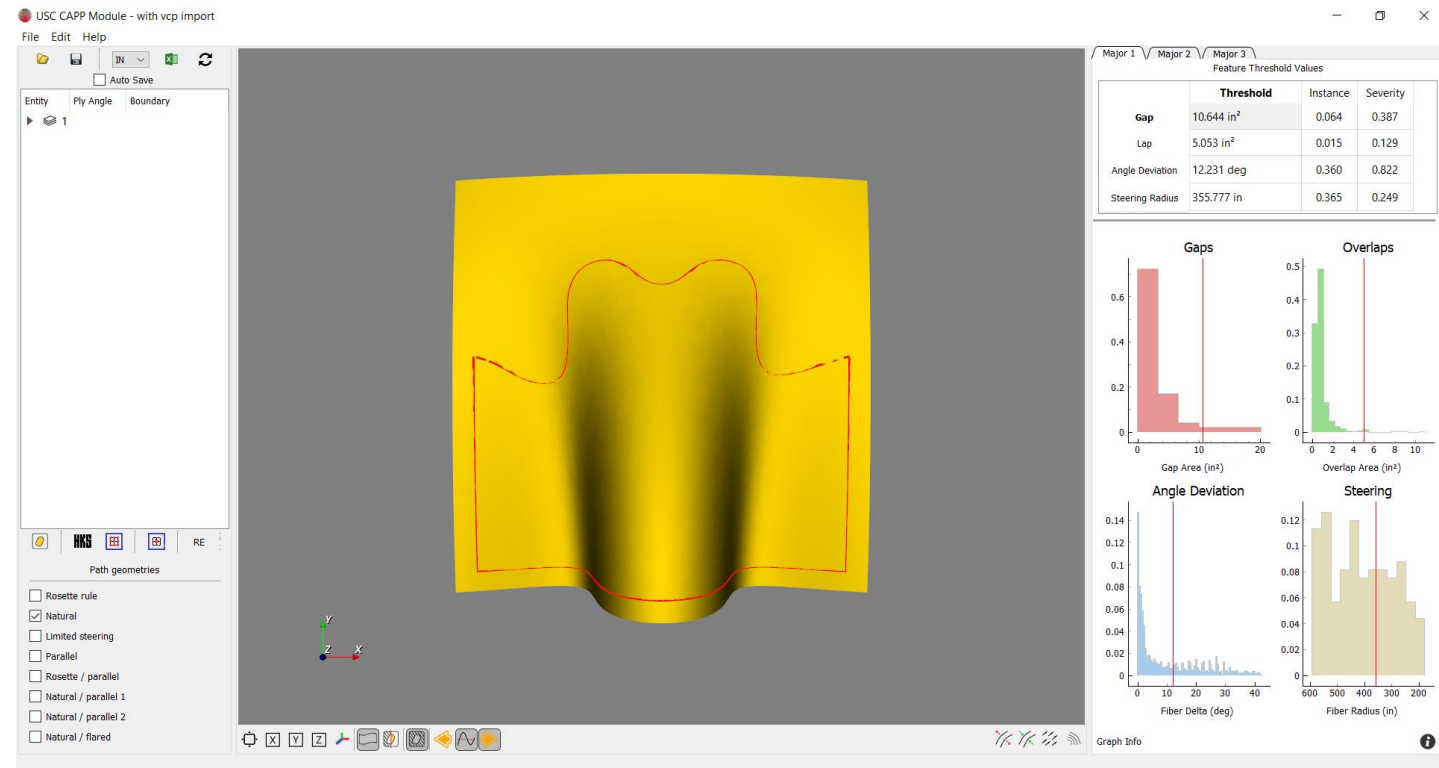
Welcome Slide – Introduce Yourself

- Joshua Halbritter
- UofSC McNAIR Center
- Graduate Research Assistant



Introduction to Computer Aided Processes Planning (CAPP)

- Composites process planning utilizes knowledge of the material system and intended design geometry
- Process planning requires domain specific knowledge about the systems in use
- CAPP intends to automate several facets of process planning and optimize for the given inputs



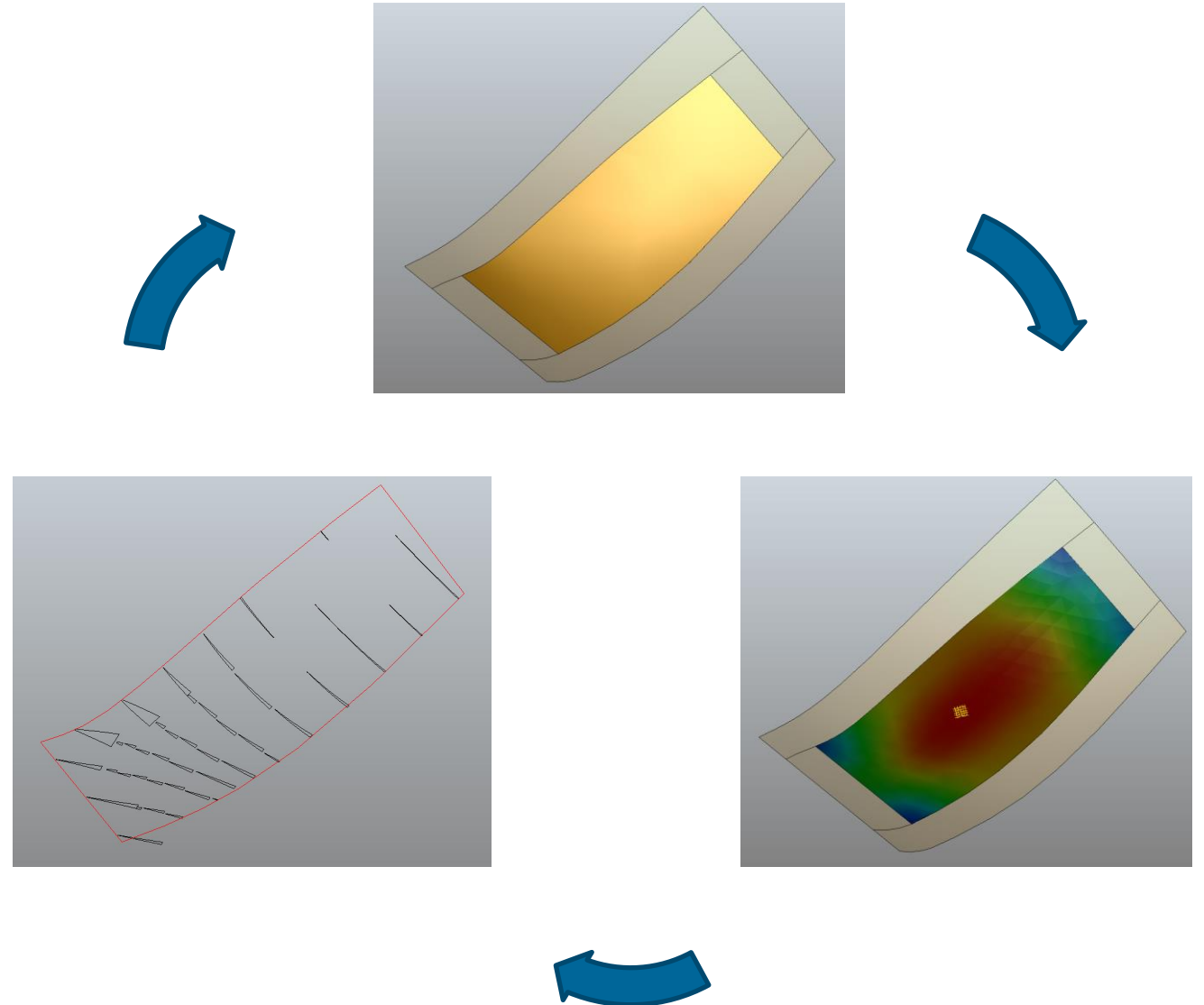
CAPP software preview

Theory of Operation

Ply Level Optimization

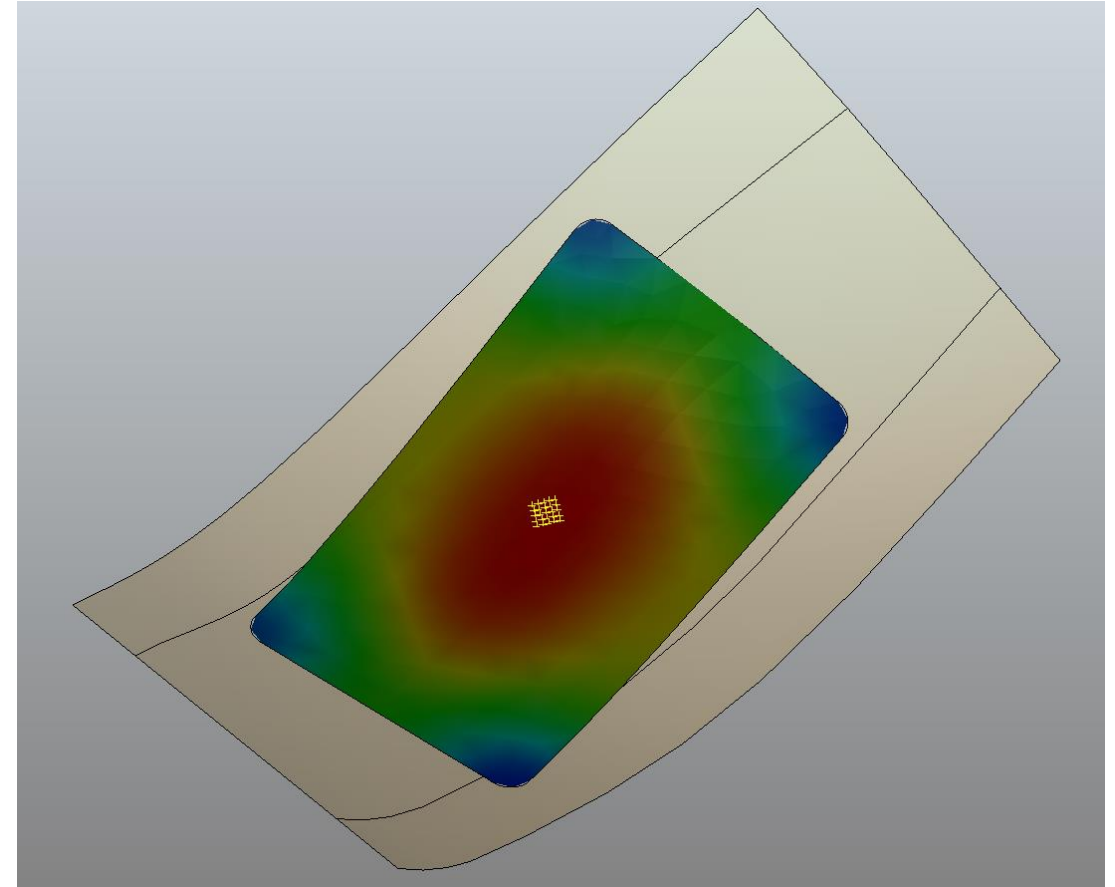
Optimization Scheme

- Inputs:
 - Ply definitions
 - Layup strategy
 - Starting point
- Outputs:
 - Populated plies
- Evaluation:
 - Resulting fiber defects



Generation of Ply Scenarios

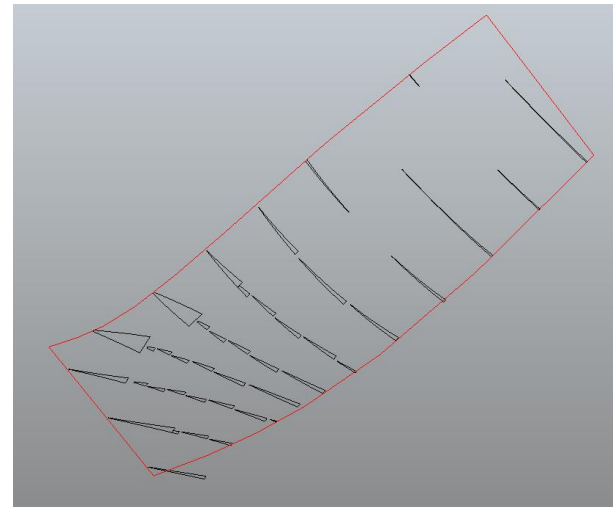
- Ply defined via boundary and fiber angle through FE techniques
- Ply scenarios represent plies with different sets of input parameters
- Layup strategy manually selected depending on tool geometry
- Starting points initialized then updated during further iterations



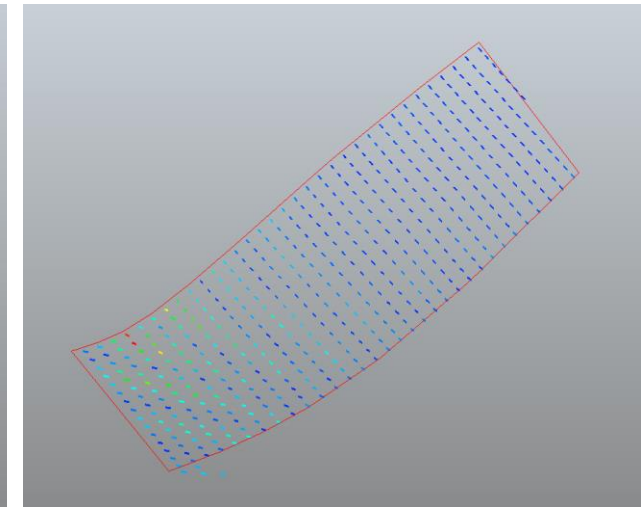
Starting point array determined by HKS

Fiber Defects and Scoring

- Optimize ply geometry for minimization of fiber defects
- Targeted fiber defects:
 - Gap and Overlap
 - Fiber angle deviation
 - Fiber steering
- Quantified via instances and severity



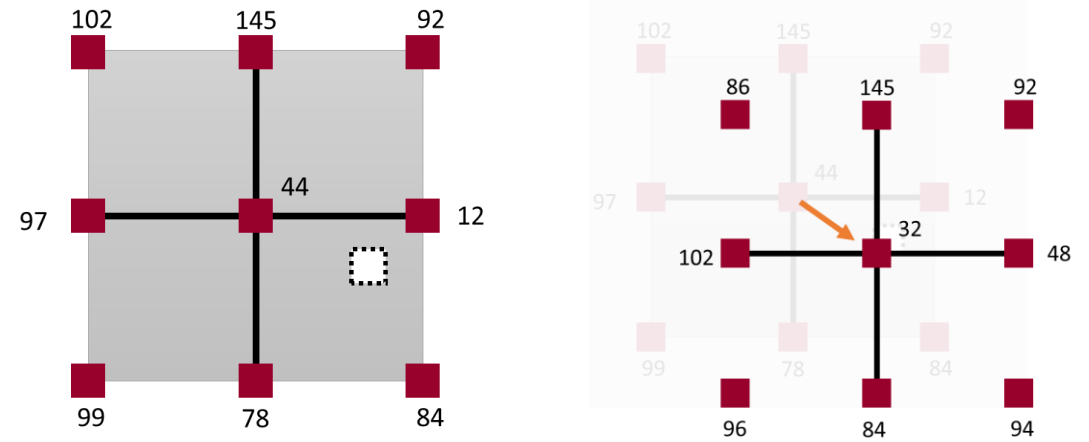
Area type defects
(Gap & overlaps)



Point type defects
(angle dev. & steering)

Scoring and Iterative Optimization

- Weighted ply score built from each defect type
- Higher defect weighting places more emphasis on reduction of that defect type
- Following iterations adjust starting point based on previous score distribution

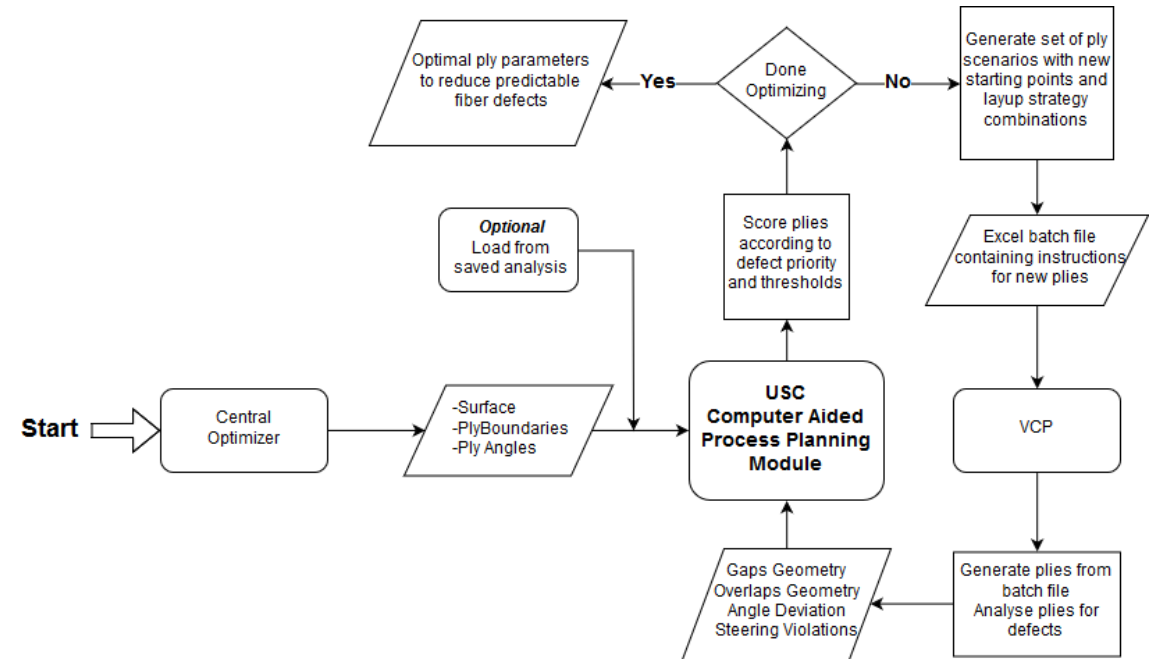


Starting point iteration step

Implementation

Inter-Software Communication

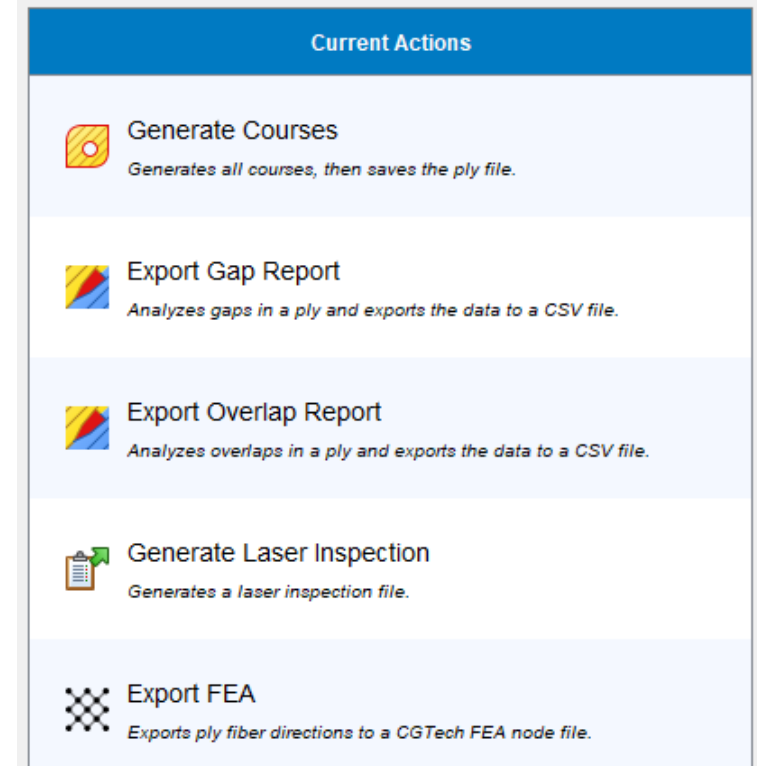
- Leverage well developed functionality of existing software
- The laminate structure is previously defined via a FE technique
- CAPP utilizes CGTech's VCP for populating ply scenarios and defect identification



Software communication flow

Batch Processing

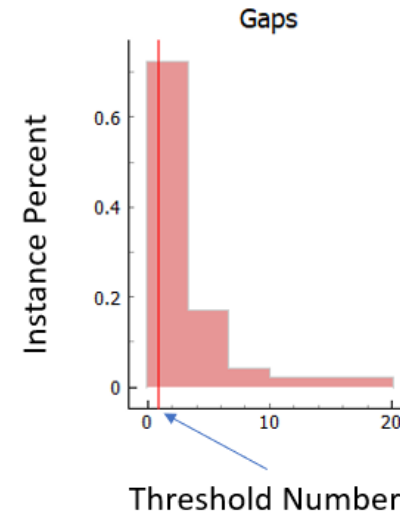
- Ply scenarios from CAPP imported to VCP through batch file interface
- A sequence of processing actions are defined in VCP
- VCP performs the actions, generating plies and defect data for CAPP to import for further analysis



Example of batch processing functionality

Extraction of Toolpath Information

- The raw defect data from VCP defines size and location of defects
- CAPP presents defect distribution through binned histograms
- Threshold adjustments define maximum allowable defect size and control defect scores



	Threshold	Instance	Severity
Gap	1 in ²	0.468	0.946
Lap	1 in ²	0.209	0.514
Angle Deviation	10 deg	0.396	0.860
Steering Radius	400 in	0.459	0.336

Defect summary and scoring

Defect Prioritization and Ranking

- Defect weighting enables operator to apply expertise towards ply optimization
- Different defect types may be less desirable for different composite applications
- Higher weighting results in more emphasis on the reduction of that defect type

	Rankings
Gap Instances	20.0%
Gap Severity	20.0%
Overlap Instances	20.0%
Overlap Severity	20.0%
Angle Deviation Instances	5.0%
Angle Deviation Severity	5.0%
Steering Instances	5.0%
Steering Severity	5.0%

	Rankings
Gap Instances	3.3%
Gap Severity	3.3%
Overlap Instances	3.3%
Overlap Severity	3.3%
Angle Deviation Instances	3.3%
Angle Deviation Severity	3.3%
Steering Instances	40.0%
Steering Severity	40.0%

Default coverage and steering weightings

Propagation and Solution Optimization

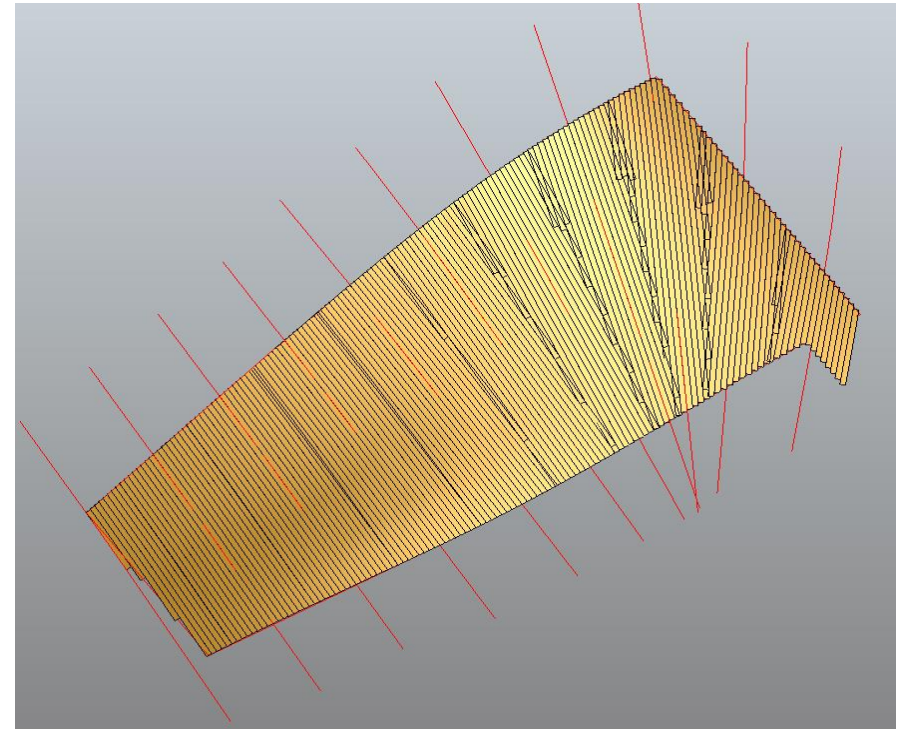
- Final ply scenario scores obtained from defect distributions and supplied weighting
- Scores presented along with the defined inputs
- Subsequent iterations adjust using the ply scenarios scores

Major 1 Major 2 Major 3		
Starting Points	Layup Strategies	
	Natural	Limited steering
	SP #1	0.534 0.546
	SP #2	0.551 0.562
	SP #3	0.542 0.537
	SP #4	0.536 0.540
	SP #5	0.548 0.218
	SP #6	0.083 0.083
	SP #7	0.082 0.083
	SP #8	0.084 0.220
	SP #9	0.082 0.082

Scoring of ply scenarios

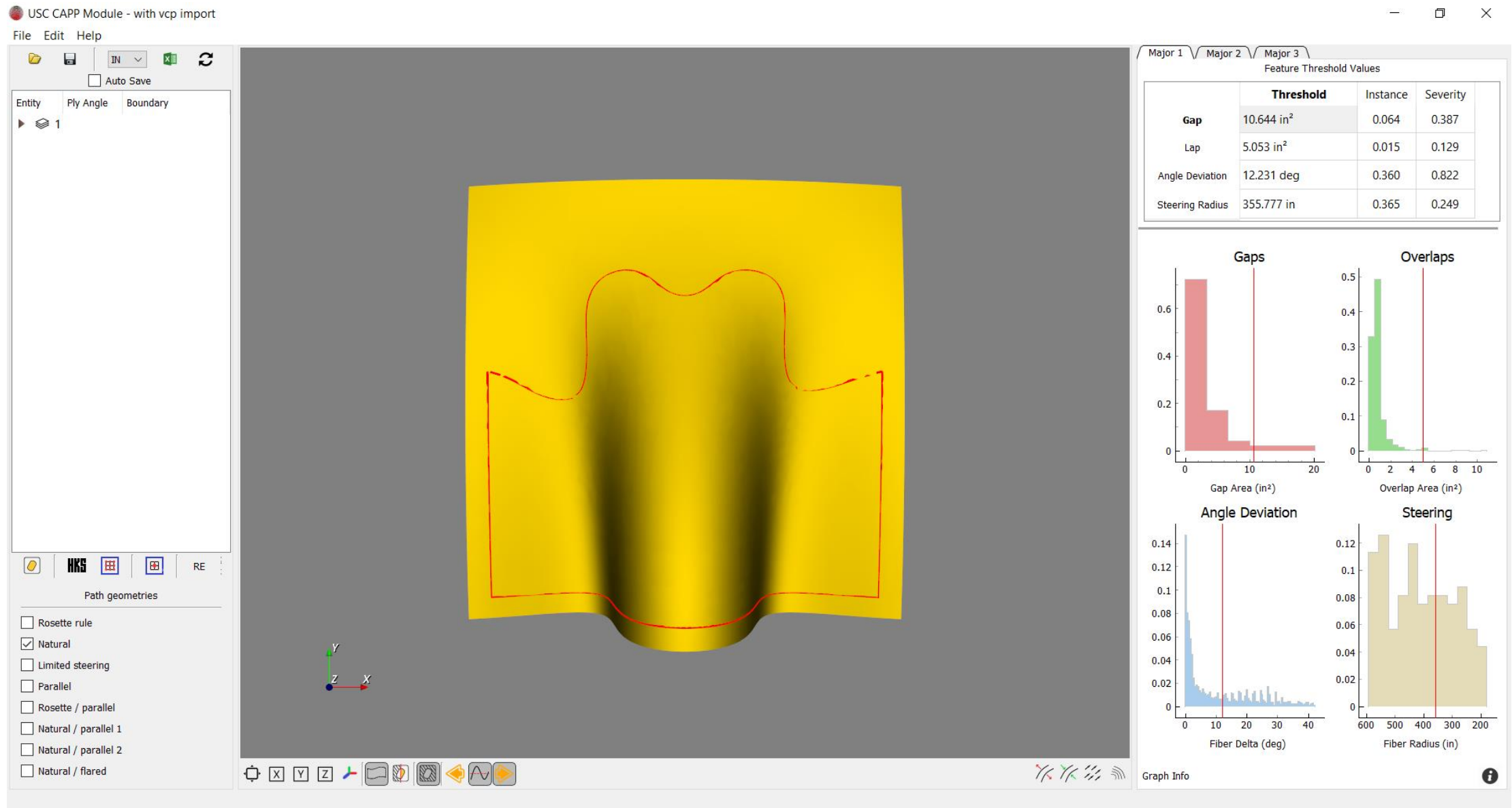
Conclusions and Future Work

- CAPP automates starting point and layup strategy selection
- Selection determined through minimization of fiber defects
- CAPP leverages and abstracts upon existing technologies
- Future work will focus on inclusion of additional process planning inputs to the optimization and new ply evaluation techniques



Courses of populated ply scenario

CAPP Software



Acknowledgements

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