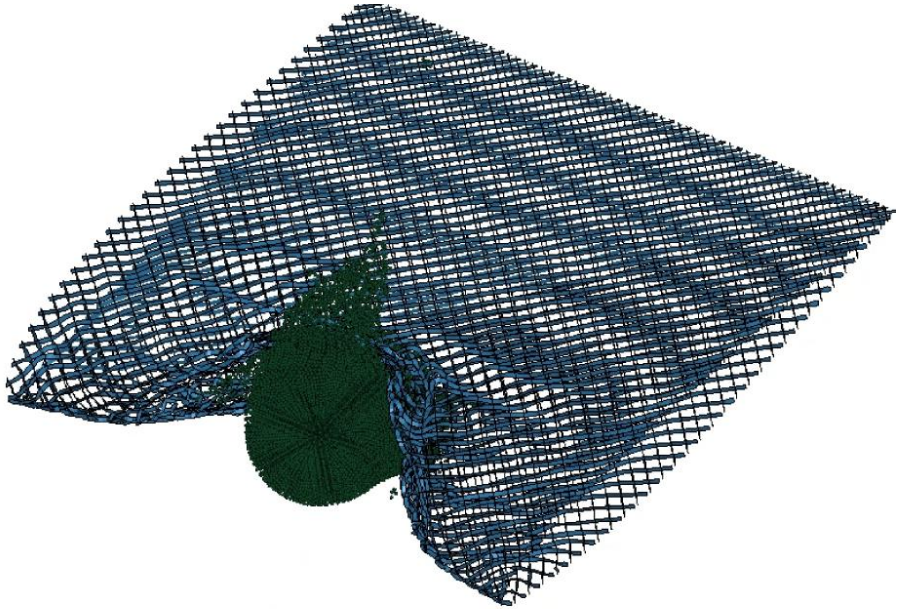
Comparison of Different Modeling Approaches for Bird Strike Analysis

Zehra Ebrar Ağca
Aday Mühendis

DynaTeam

Test Case Purpose

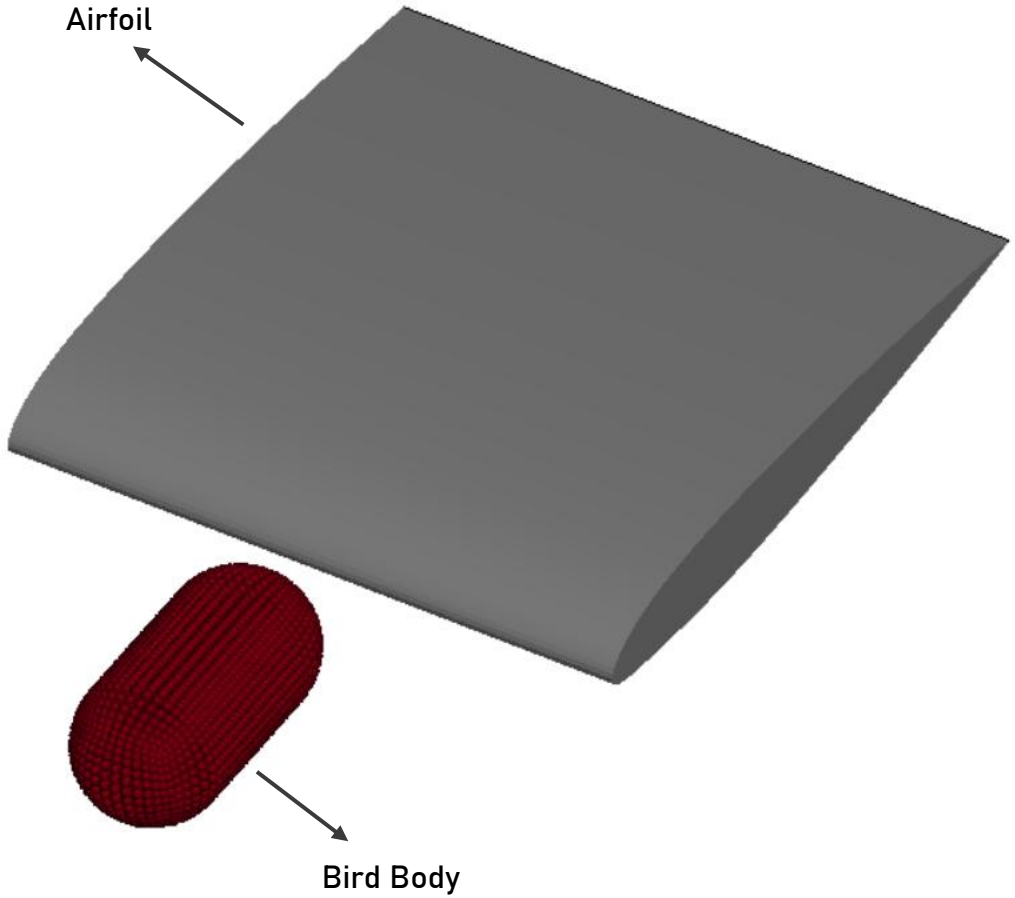
- This analysis compares different numerical modeling approaches for a bird strike simulation.
- The primary goal is to evaluate the consistency and reliability of these methods and to identify the most accurate material model for the structure.
- Additionally, the study examines the cross-CPU architecture consistency of LS-DYNA® for this specific impact scenario.



Model Description

- Smoothed Particle Hydrodynamics (SPH): The bird is represented by SPH particles, a mesh-free method often used for fluid-like behavior.
- Arbitrary Lagrangian-Eulerian (ALE): The bird is represented by a volume fraction distribution within an ALE computational domain, which is ideal for large deformations.
- ALE w/ Reference System Group (RSG): The ALE domain moves and stretches together with the bird during impact. This approach allows the use of a smaller computational domain while maintaining accuracy, which significantly reduces simulation time and computational cost.
- Structured ALE (S-ALE): A modern alternative to the traditional ALE method that automates mesh-generation.

Test Case Description

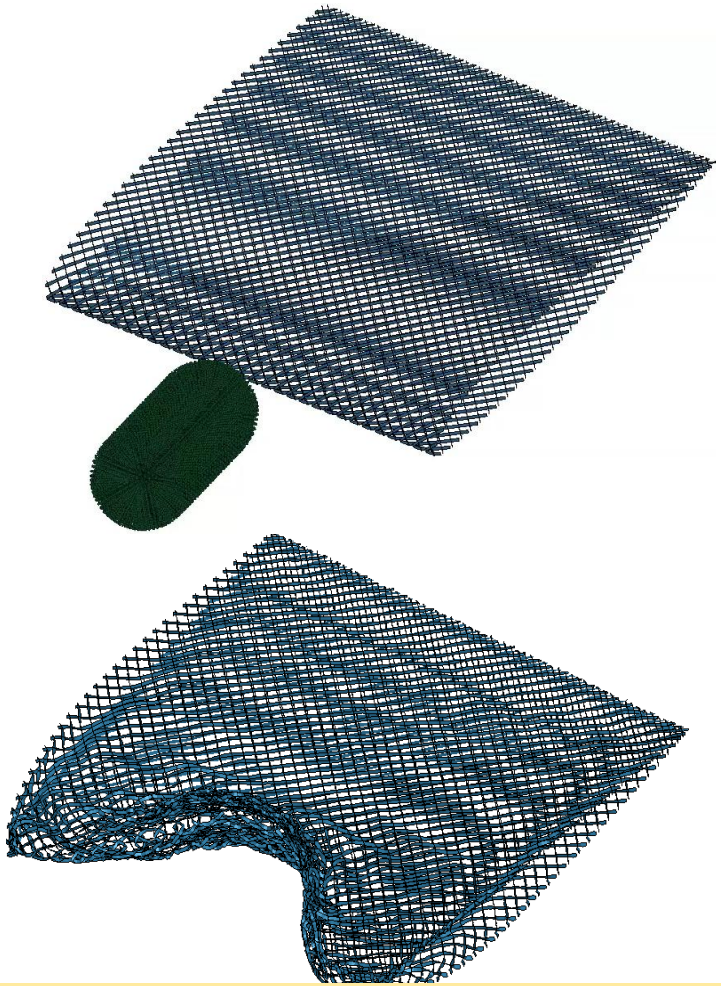


Airfoil Material: AA2024-T3	*MAT_015 [1] and *MAT_224 [2]
Reinforcement: AA2024-T3	*MAT_015 [1] and *MAT_224 [2]
Bird Geometry	Length = 226.8 mm, Diameter = 113.4 mm
Bird Material	*ELASTIC_PLASTIC_HYDRO [3]
Bird Velocity	$V_{initial}$ = 264 mm/ms

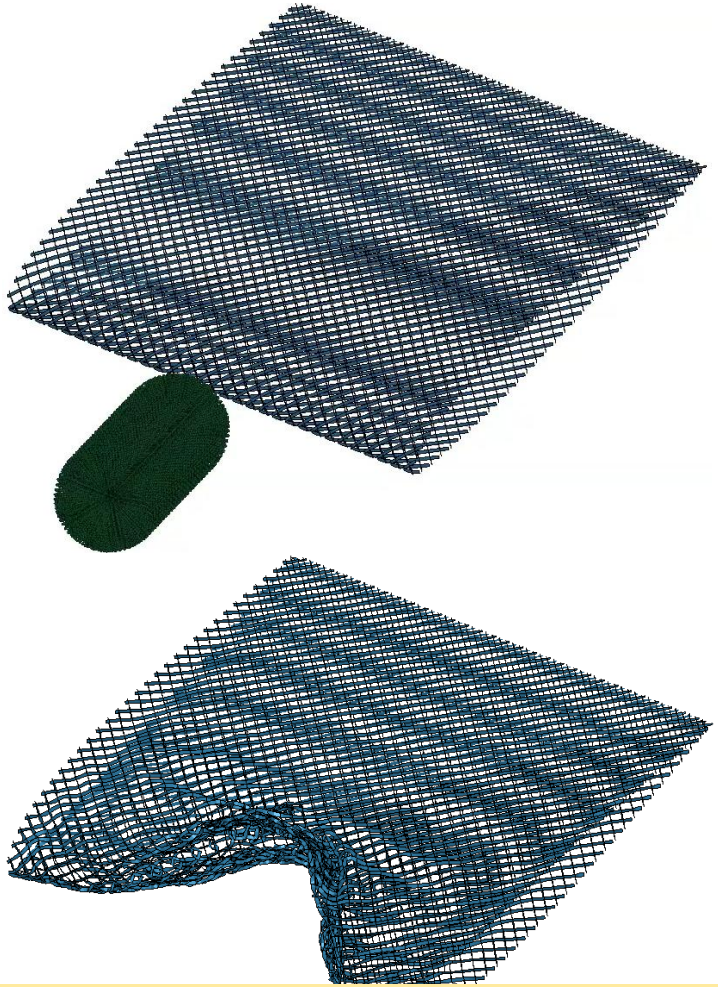
For the animation results, please go to the link: https://www.youtube.com/watch?v=ETbBXjgdxMA

Material Verification Case I | SPH Bird Impact on Al 2024-T3 Airfoil

*MAT_15



*MAT_224



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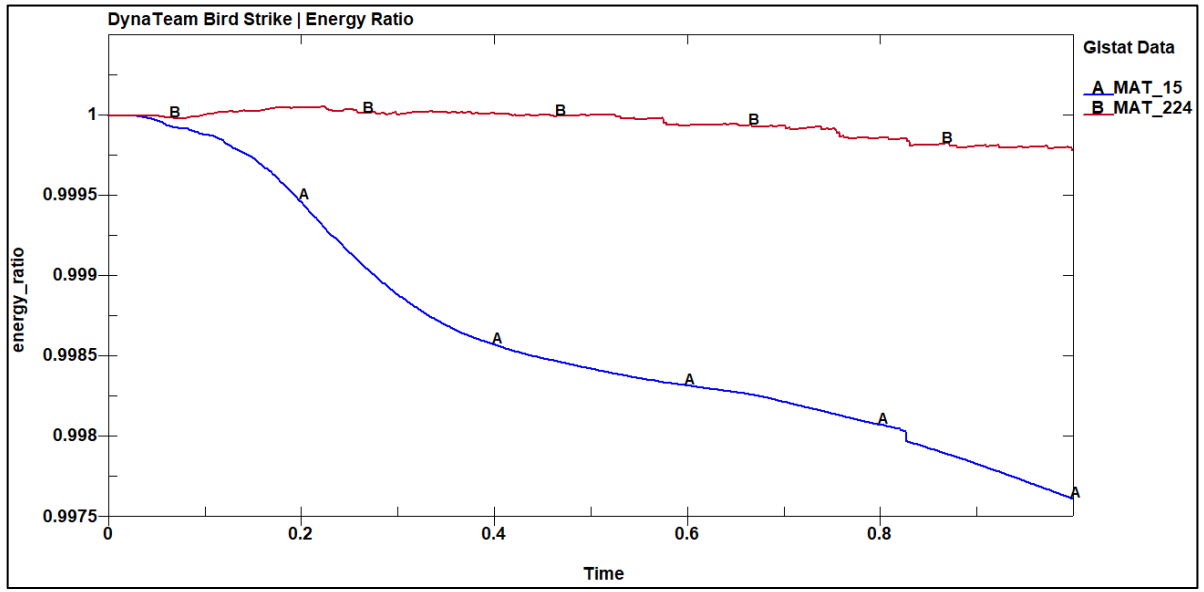
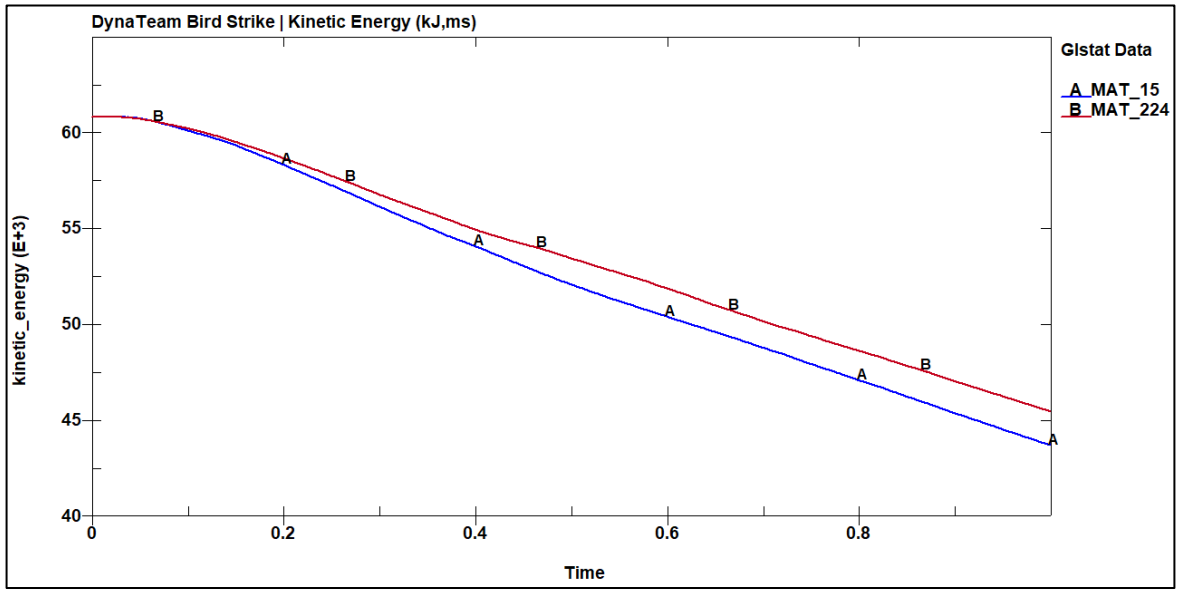
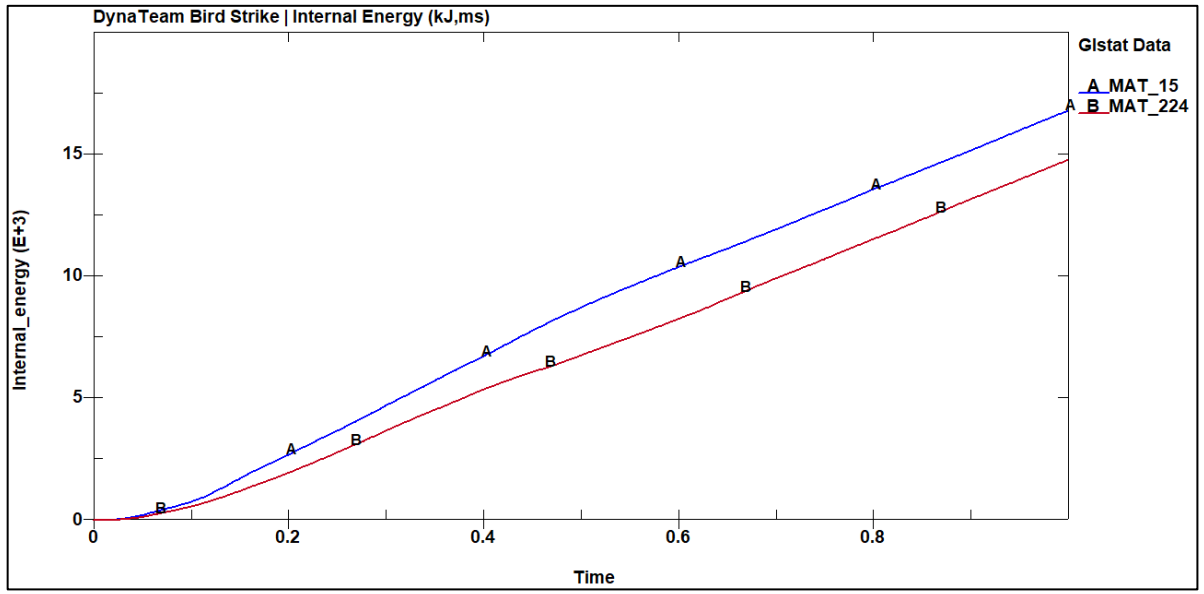
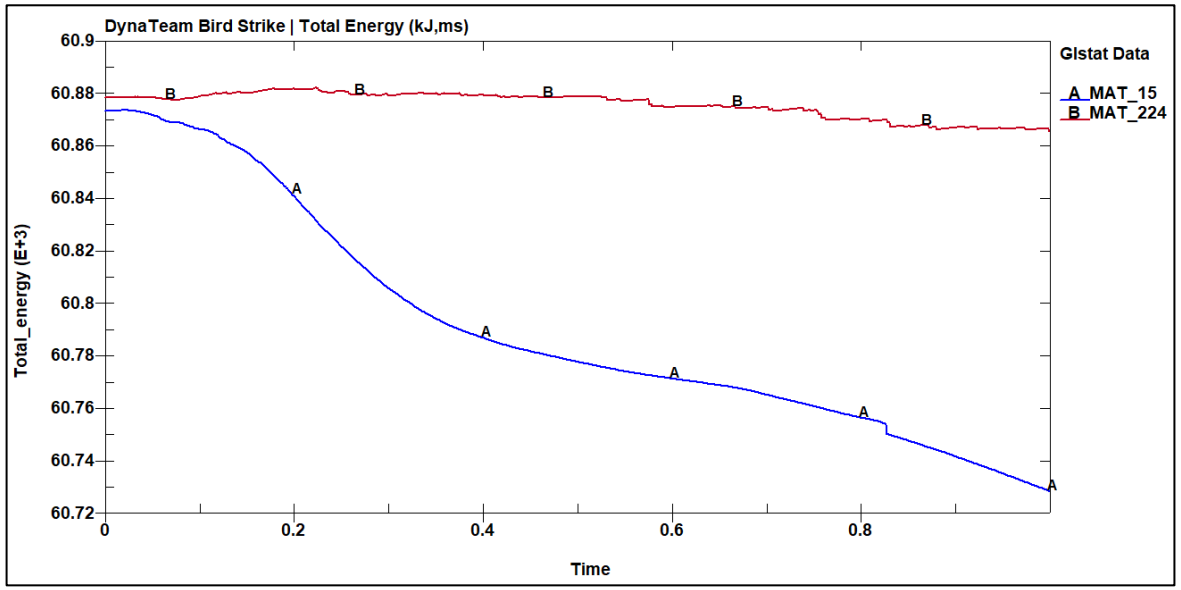
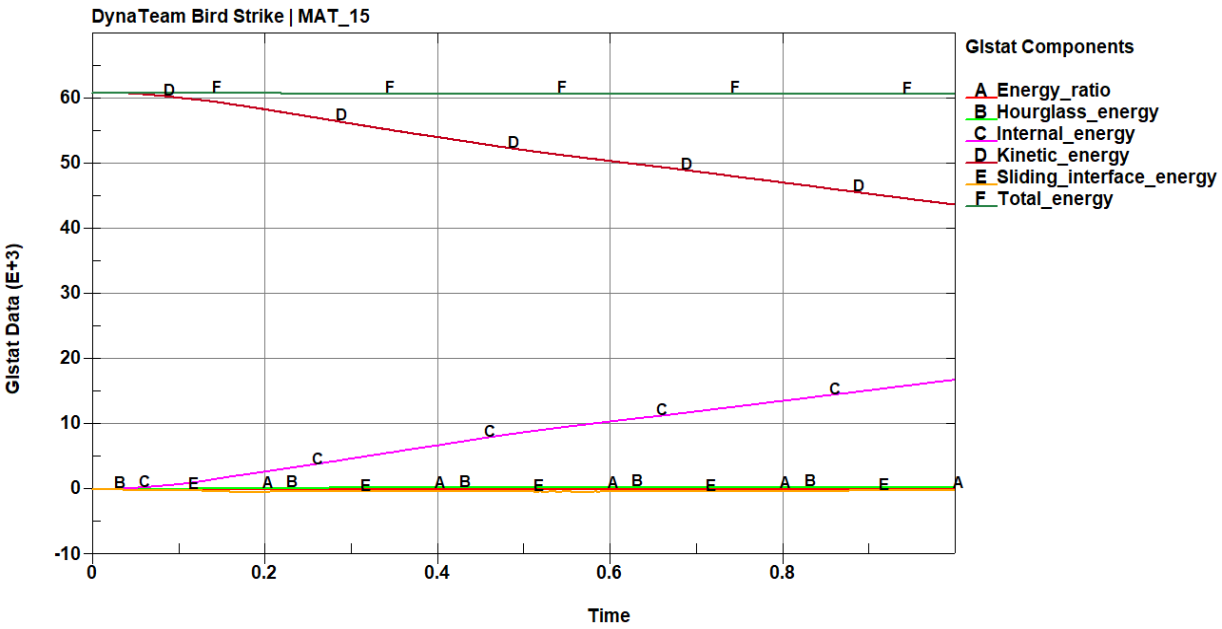

DynaTeam Bird Strike | Energy Ratio
Glstat Data
A MAT_15
B MAT_224
energy_ratio
1
0.9995
0.999
0.9985
0.998
0.9975
0
0.2
0.4
0.6
0.8
Time


DynaTeam Bird Strike | Kinetic Energy (kJ,ms)
Glstat Data
A MAT_15
B MAT_224
kinetic_energy (E+3)
60
55
50
45
40
0
0.2
0.4
0.6
0.8
Time

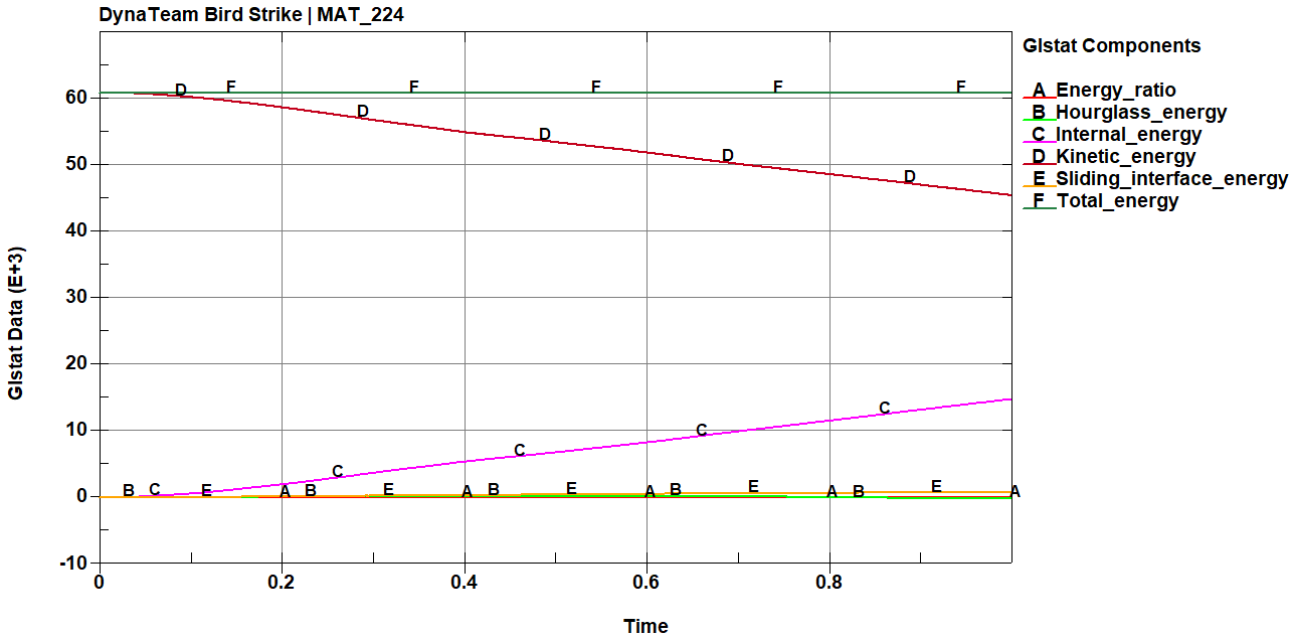

DynaTeam Bird Strike | Internal Energy (kJ,ms)
Glstat Data
A MAT_15
B MAT_224
Internal_energy (E+3)
15
10
5
0
0
0.2
0.4
0.6
0.8
Time


DynaTeam Bird Strike | Total Energy (kJ,ms)
Glstat Data
A MAT_15
B MAT_224
Total_energy (E+3)
60.9
60.88
60.86
60.84
60.82
60.8
60.78
60.76
60.74
60.72
0
0.2
0.4
0.6
0.8
Time

*MAT_15

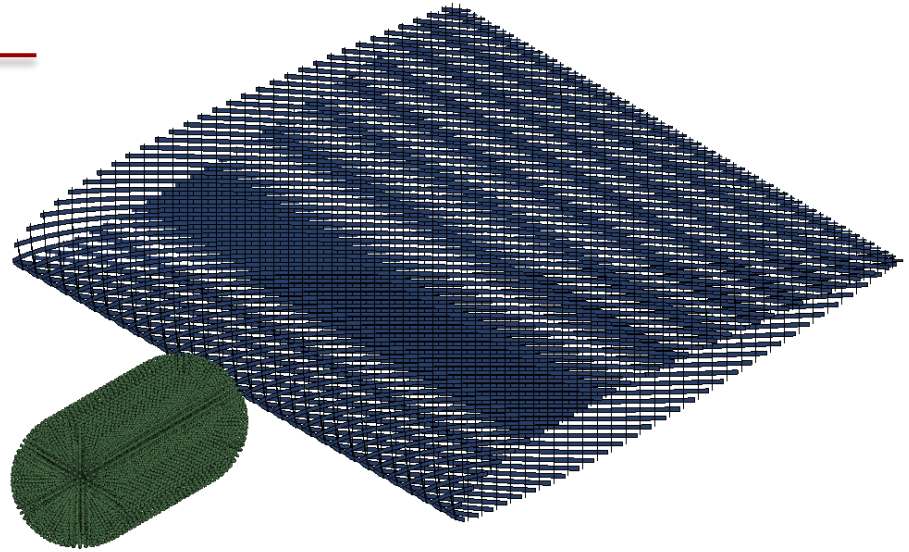


*MAT_224

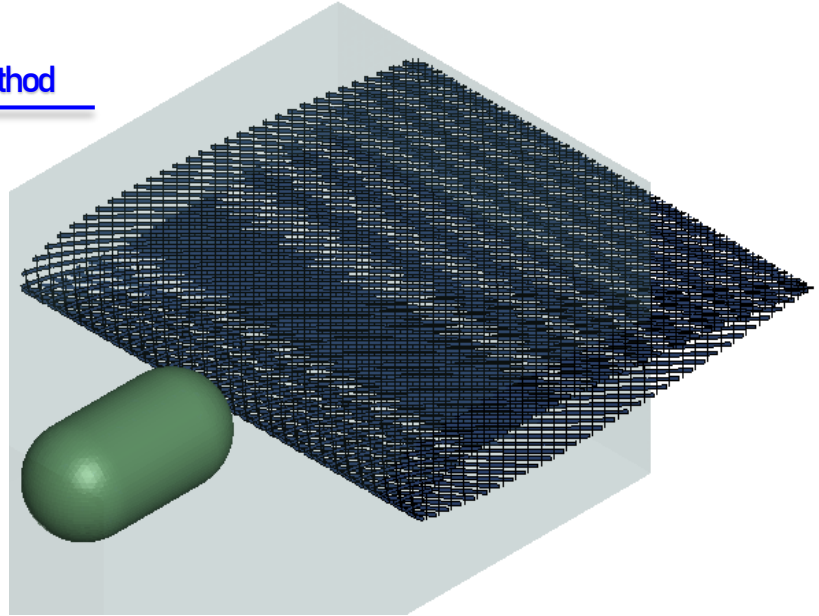


- Both material models produced consistent deformation and energy responses. Both *MAT_*015 and *MAT_224 exhibited smooth energy transitions and stable behavior under high strain-rate loading. Further studies will utilize *MAT_224_TABULATED_JOHNSON_COOK to compare different bird modeling techniques.

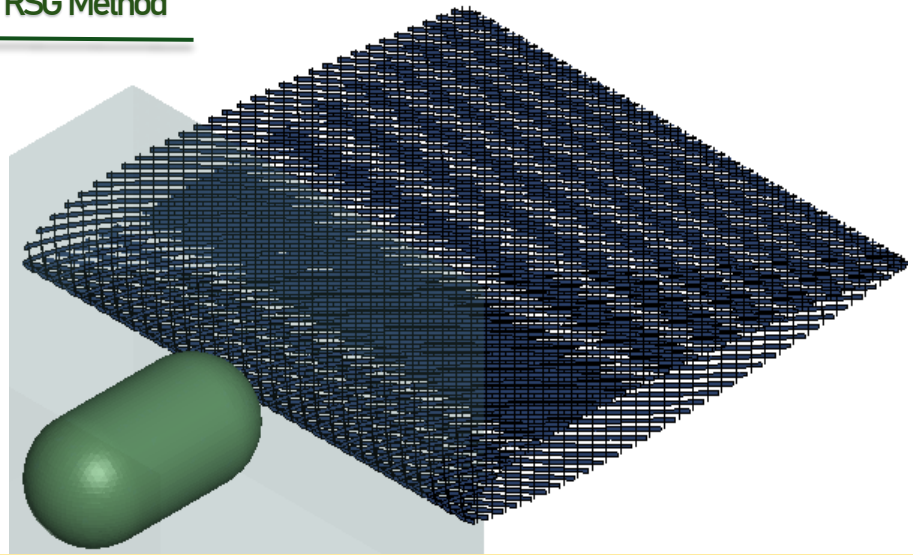
Case I | SPH Method



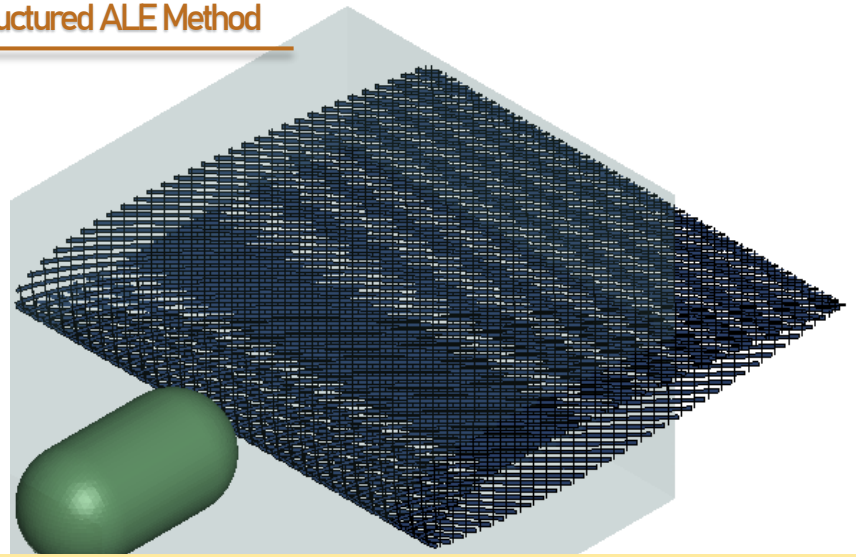
Case II | ALE Method



Case III | ALE w/ RSG Method



Case IV | Structured ALE Method



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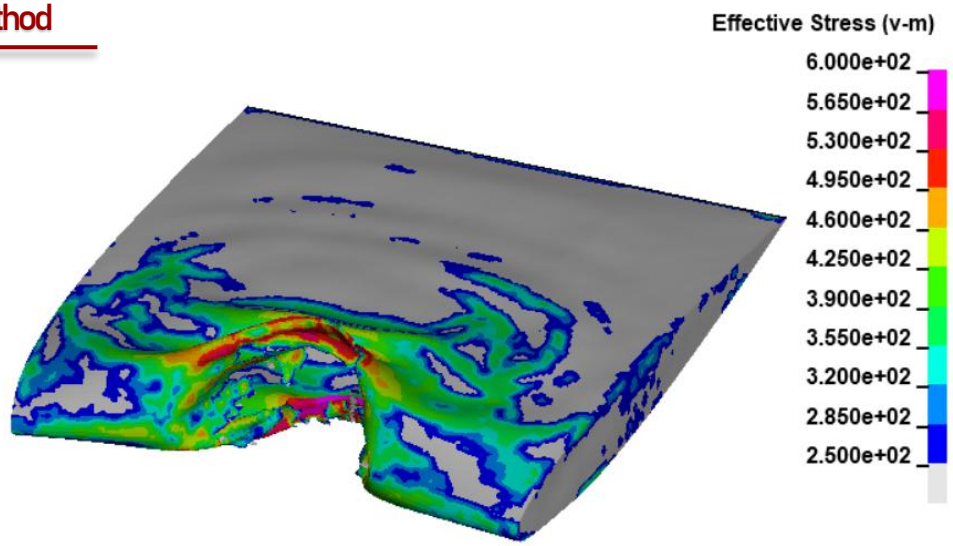
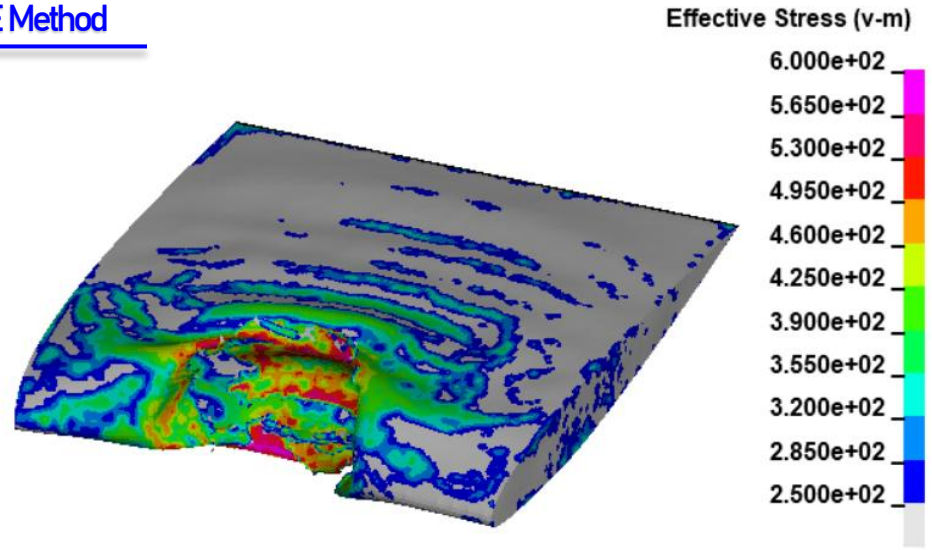
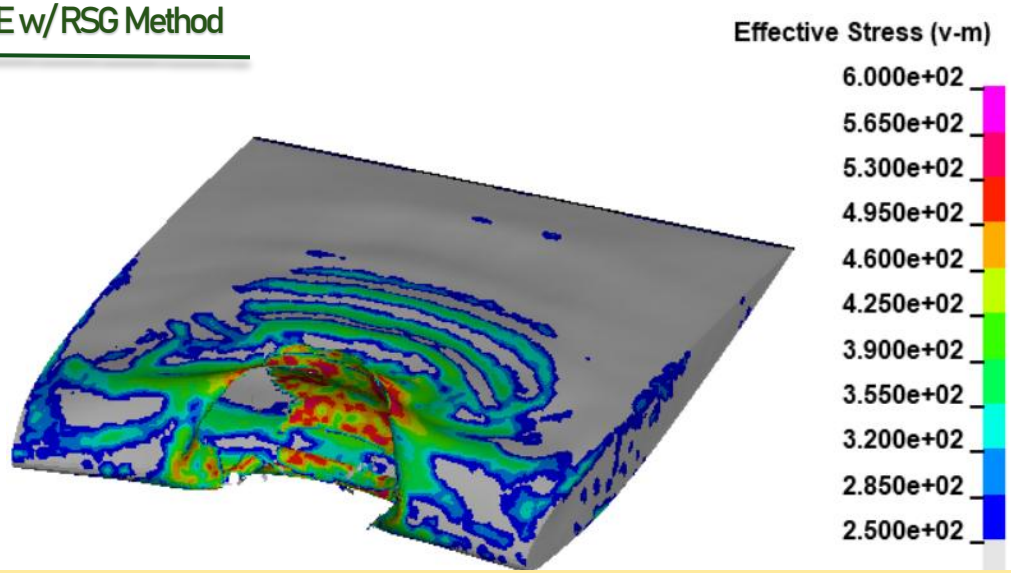
Case I | SPH Method



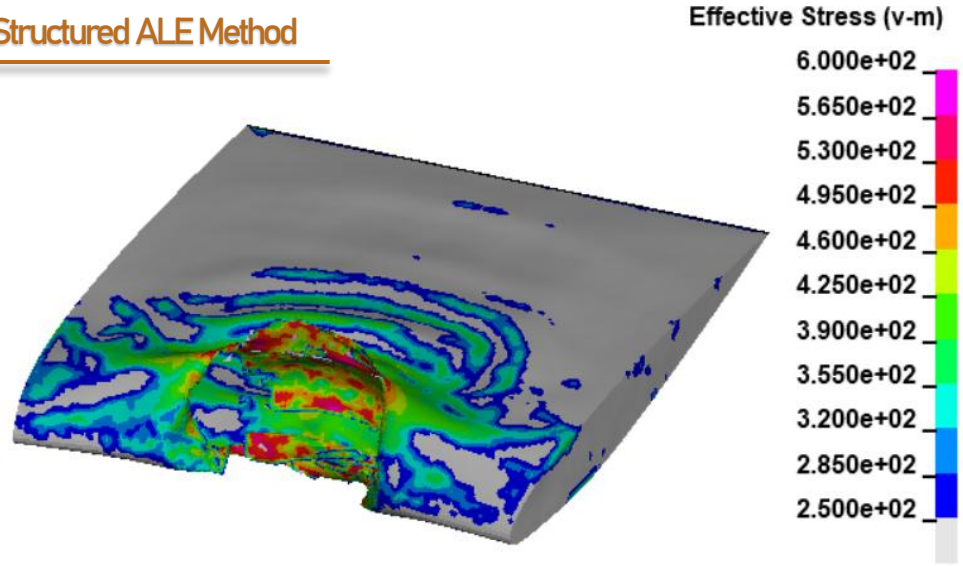
Case II | ALE Method



Case III | ALE w/ RSG Method



Case IV | Structured ALE Method



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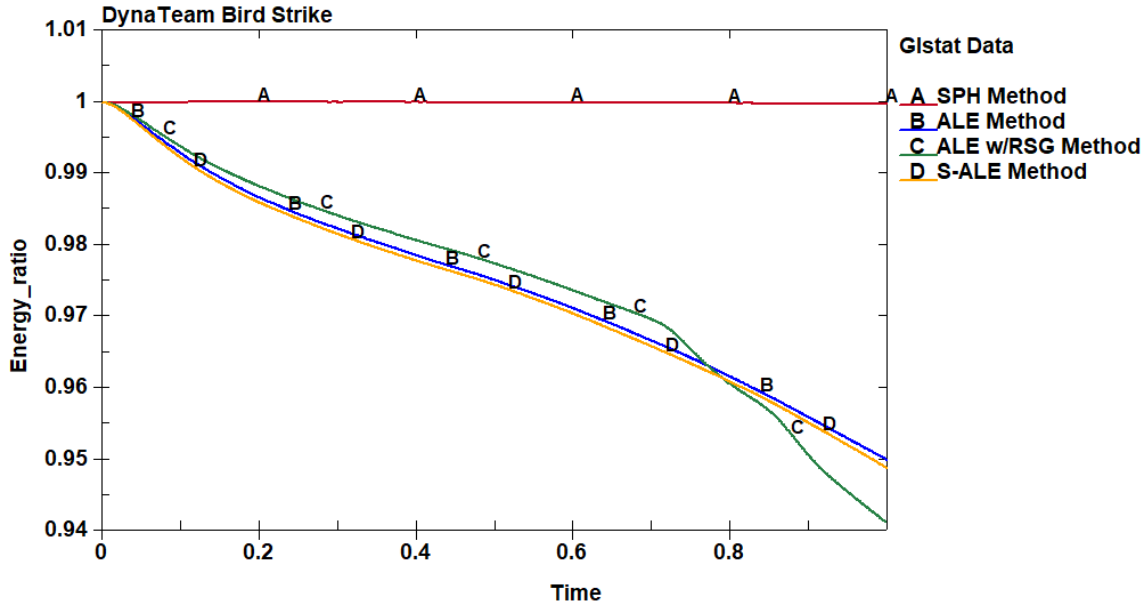
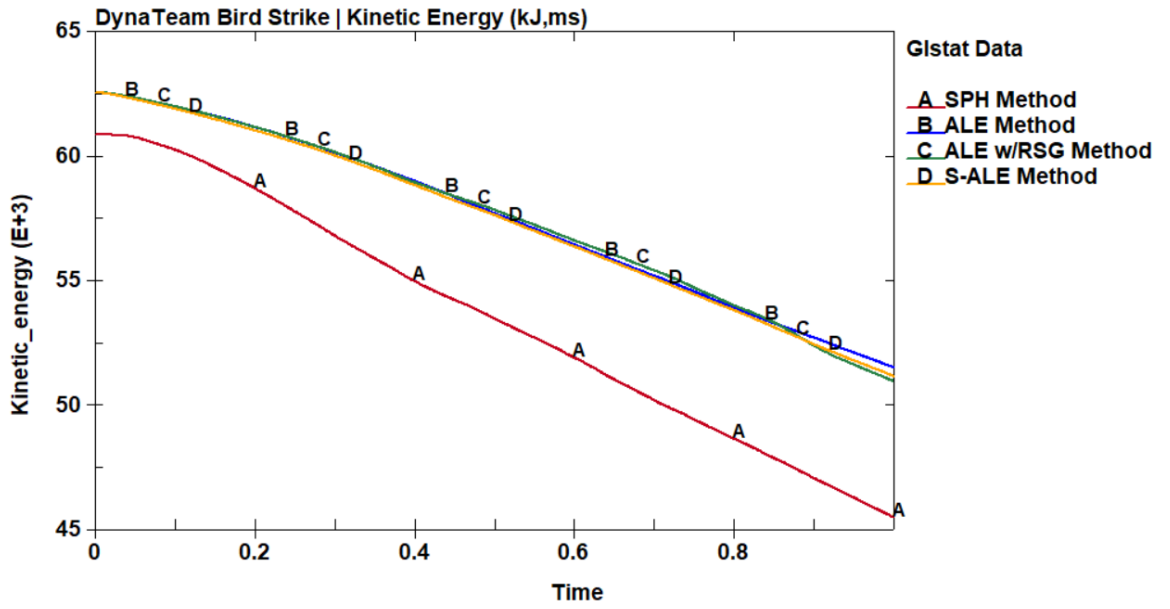
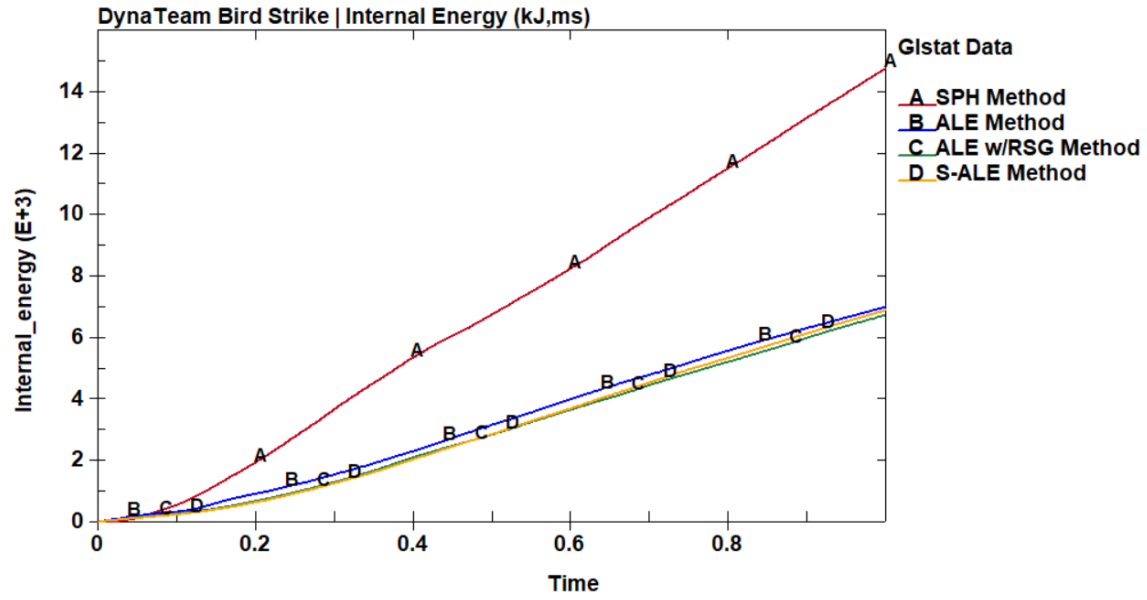
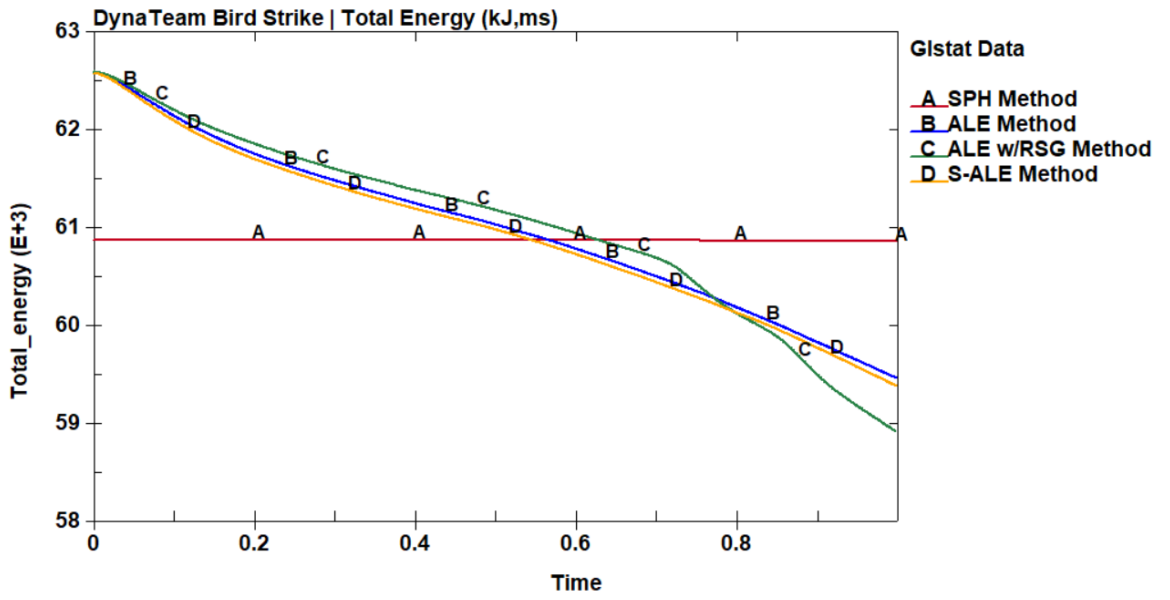
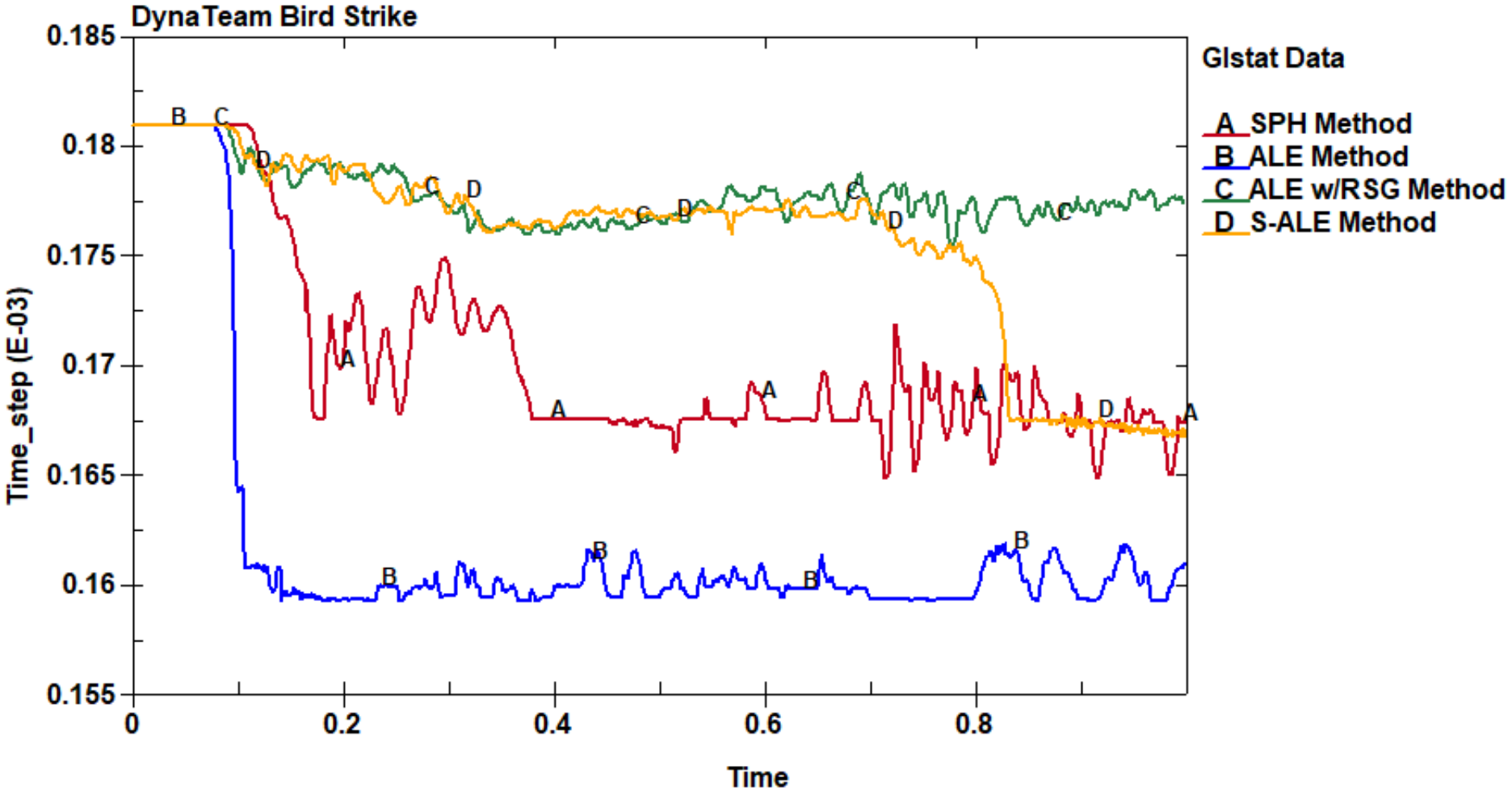

DynaTeam Bird Strike
Energy_ratio
Time
Glstat Data
A SPH Method
B ALE Method
C ALE w/RSG Method
D S-ALE Method


DynaTeam Bird Strike | Kinetic Energy (kJ,ms)
Kinetic_energy (E+3)
Time
Glstat Data
A SPH Method
B ALE Method
C ALE w/RSG Method
D S-ALE Method


DynaTeam Bird Strike | Internal Energy (kJ,ms)
Internal_energy (E+3)
Time
Glstat Data
A SPH Method
B ALE Method
C ALE w/RSG Method
D S-ALE Method


DynaTeam Bird Strike | Total Energy (kJ,ms)
Total_energy (E+3)
Time
Glstat Data
A SPH Method
B ALE Method
C ALE w/RSG Method
D S-ALE Method



n.b. The time step was controlled by the reinforcement part for all the cases.

CPU Time Comparison of Modeling Methods

Model	Total CPU Time
SPH Method	6 minutes 42 seconds
ALE Method	40 minutes 56 seconds
ALE w/RSG Method	26 minutes 10 seconds
S-ALE Method	28 minutes 11 seconds

All simulations were performed using the LS-DYNA R16.0 solver (MPP, single precision) on an Intel Core i7-11700 with 8 cores to ensure consistency across all methods.

References

[1] G. S. E. Bikakis, C. D. Dimou, and E. P. Sideridis, “Ballistic impact response of fiber–metal laminates and monolithic metal plates consisting of different aluminum alloys,” Aerosp Sci Technol, vol. 69, pp. 201–208, Oct. 2017, doi: 10.1016/J.AST.2017.06.028.

[2] “Material Parameter Sets | LS-DYNA Aerospace Working Group.” Accessed: Oct. 14, 2025. [Online]. Available: https://awg.ansys.com/Material+Parameter+Sets

[3] M. F. Sarıbaş and S. Karadeniz, “Bir Uçak Kanadının Hücum Kenarına Kuş Çarpmasının Düzgün Parçacık Hidrodinamiği Yöntemiyle Sayısal İncelenmesi,” Gazi Journal of Engineering Sciences, vol. 8, no. 3, pp. 547–566, Dec. 2021, doi: 10.30855/GMBD.0705042.

DynaTeam

Simulation of tomorrow, reality of today.

Info and Support

info@dynateam.com.tr
destek@dynateam.com.tr

www.dynateam.com.tr