Analysis of the Presidential Plane Crash in Smolensk, Russia, on April 10, 2010

Professor Wiesław K. Binienda, Ph.D., F. ASCE
College of Engineering
Civil Engineering Department
The University of Akron
Akron, OH 44325
wbinienda@uakron.edu

Professor WIESŁAW K. BINIENDA, Ph.D., F.ASCE

- **MS –Warsaw University of Technology, SiMR**
- **PhD – Drexel University**
- **Editor-in-Chief– Journal of Aerospace Engineering, American Society of Civil Engineers ("ASCE")**
- **ASCE Fellow**
- **Chairman of the Civil Engineering Department The University of Akron ("UA"), Ohio, USA**
- **Director of the "UA Gas Turbine Facility"**

- www.ecgf.uakron.edu/~civil/people/binienda/
- www.uakroncivil.com/researchlab/

Members of the Aerospace Consortium

- Arizona State University (ASU)
- Boeing
- Central Connecticut State University (CCSU)
- Federal Aviation Administration (FAA)
- General Electric Aviation (GE)
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- Goodrich
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- Rolls-Royce
- Snecma
- SRI International
- The University of Akron – Dr. Wieslaw K. Binienda
- Williams International

Question

Is it possible that the airplane Tu-154M lost a major part of the wing as a result of hitting the Birch Tree?

Methodology of Analisis

LsDyna3D Simulation

Parameters:

- Plane speed: **70 m/s to 80 m/s**
- Plane mass: **78600 kg**
- Distance from the base to the tree cut: **5m to 6m**
- Birch diameter at the cut area: **40 cm**
- Location of the impact on the wing from its tip: **3m - 7m**
- Several orientations - angles from **5 to 20 degrees**

Similar analysis

- Purdue University – Analysis of the terrorist attack of the World Trade Center on September 11, 2001.

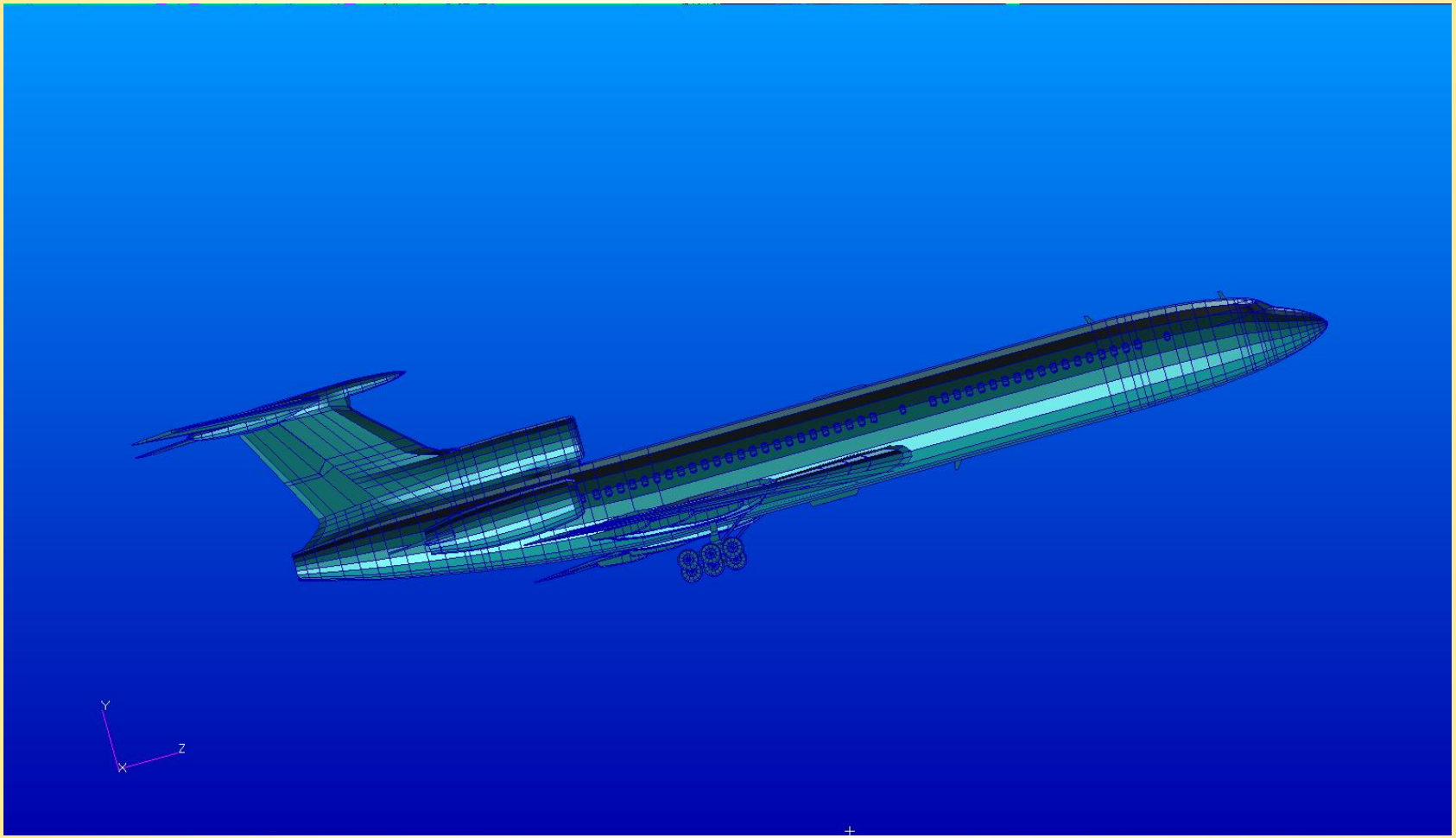
- http://www.youtube.com/watch?v=cddIgb1nGJ8

  - Wing of the plane cut through the steel members

Material Models

- **Birch**- elastic, cylindrically orthotropic
- **Aluminum**: isotropic, elastoplastic hardened, or J-C with strain rate dependent parameters

Model Tu-154M



Internal Wing Design Tu-154M

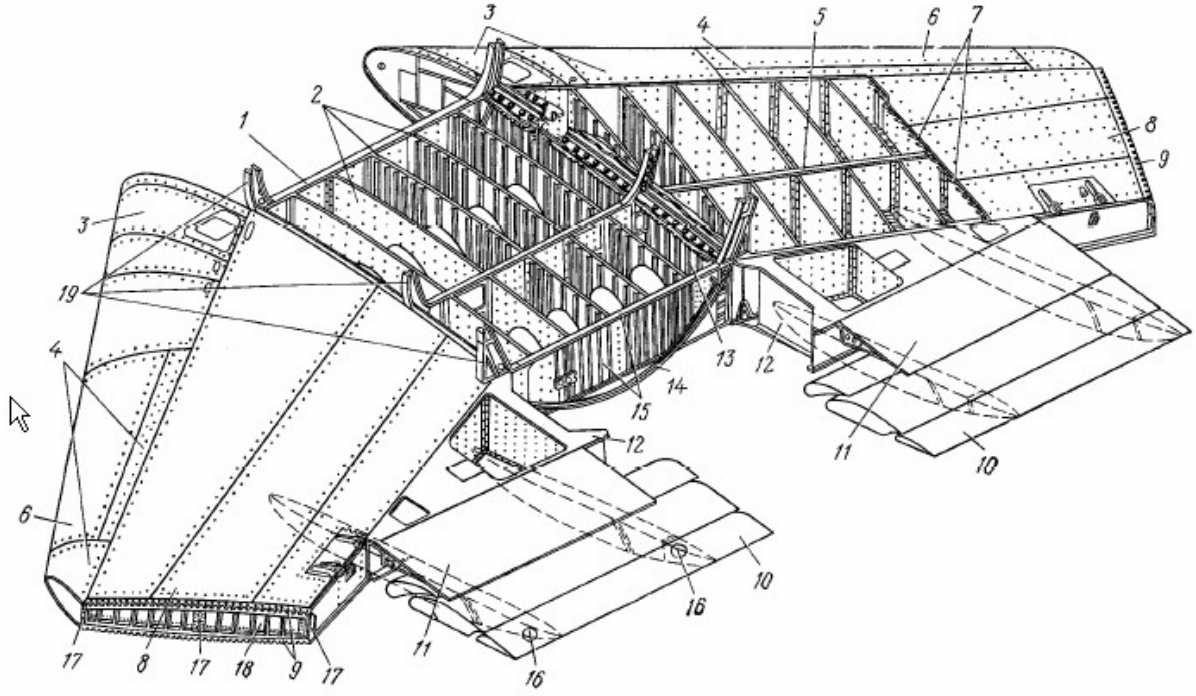


Рис. 2.33. Центроплан крыла:
1—передний лонжерон; 2—нервюры; 3—съемный носок (первый); 4— съемный носок (второй); 5—средний лонжерон; 6—внутренний предкрылок; 7—стрингеры; 8— съемная панель; 9—профили разъема; 10— внутренний закрылок; 11—внутренний интерцептор; 12—хвостовая часть; 13—нервюра № 3; 14—профиль; 15—задний лонжерон; 16—балка механизма закрылка; 17—стыковая стойка; 18—нервюра № 14; 19—узлы крепления центроплана к фюзеляжу

Internal Wing Design Tu-154M

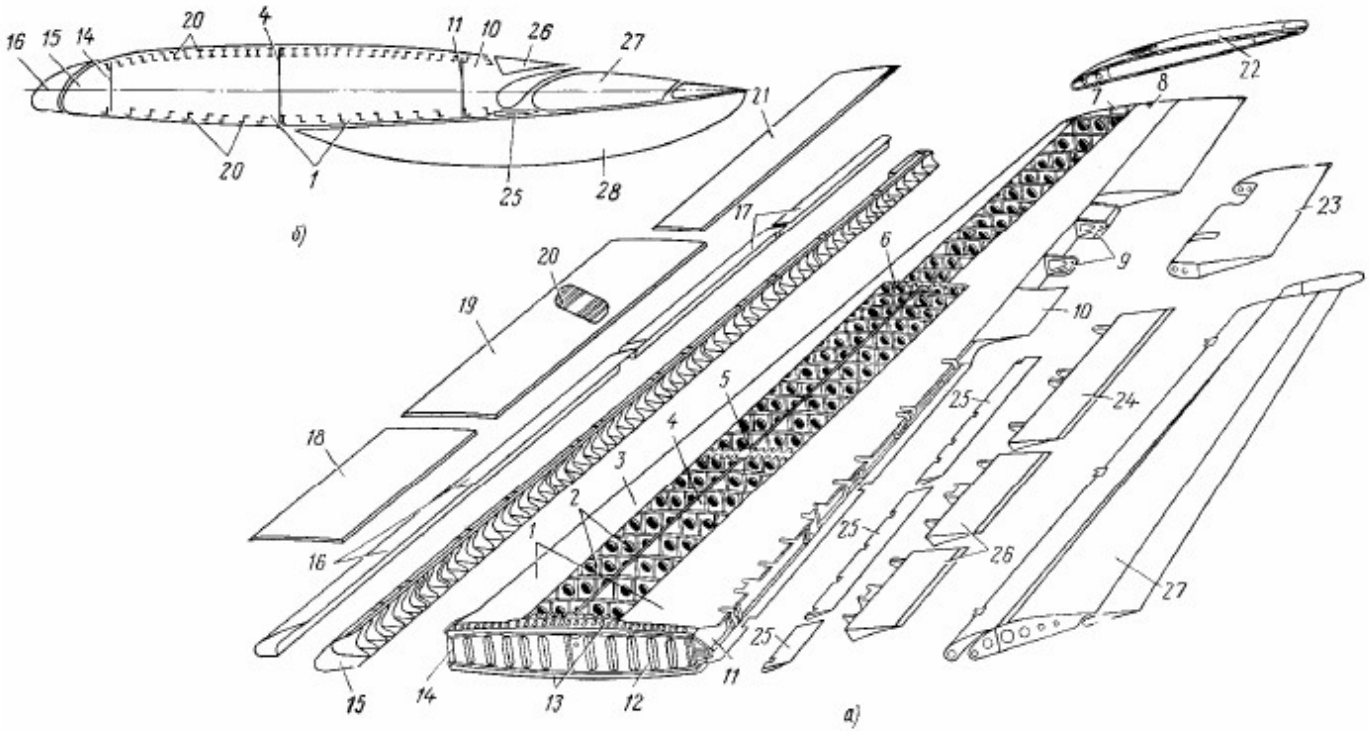


Рис. 2.37. Отъемная часть крыла (аэродинамические перегородки не показаны): а—общий вид; б—сечение ОЧК по нервюре № 18; 1—кессон; 2—нервюры; 3—первая технологическая панель; 4—средний лонжерон; 5, 6—стыковочные профили; 7—нервюра №. 45; 8—вторая технологическая панель; 9—кронштейны подвески элерона; 10—

Internal Wing Design Tu-154M

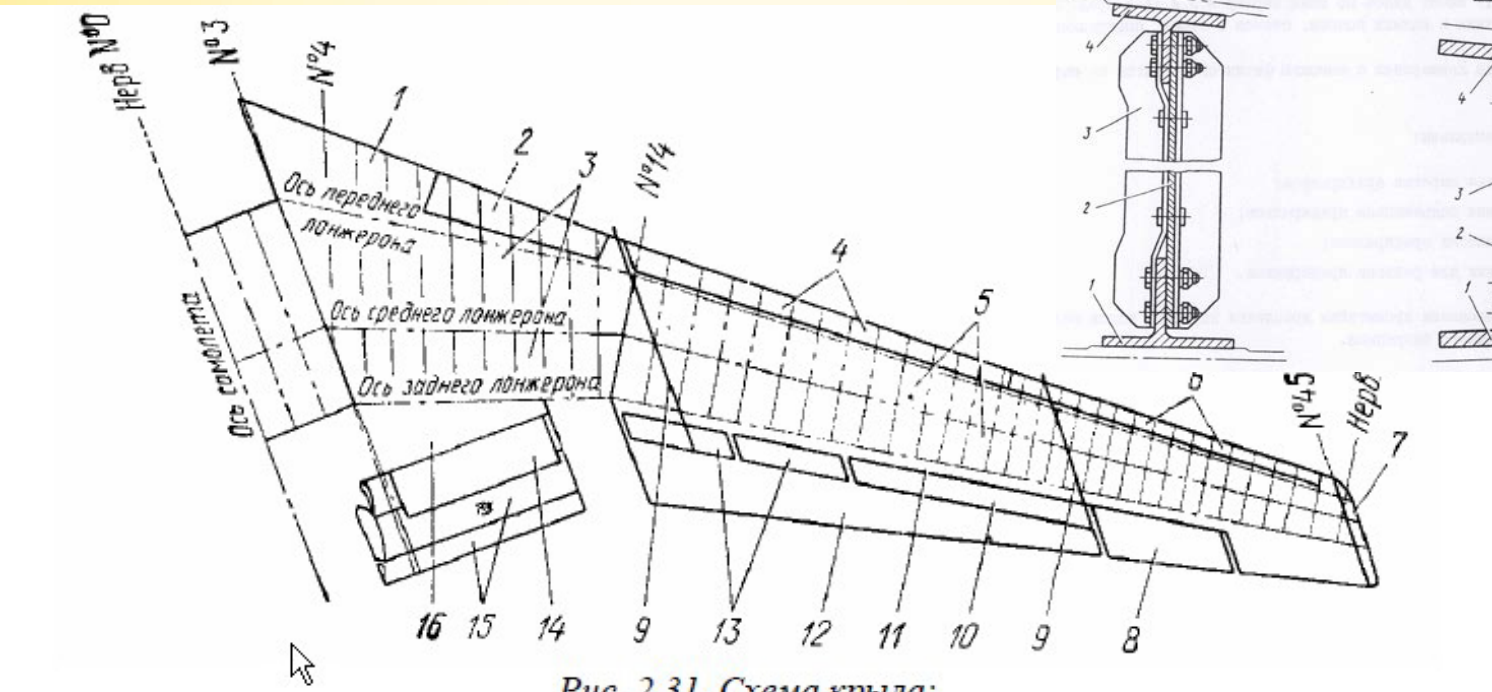
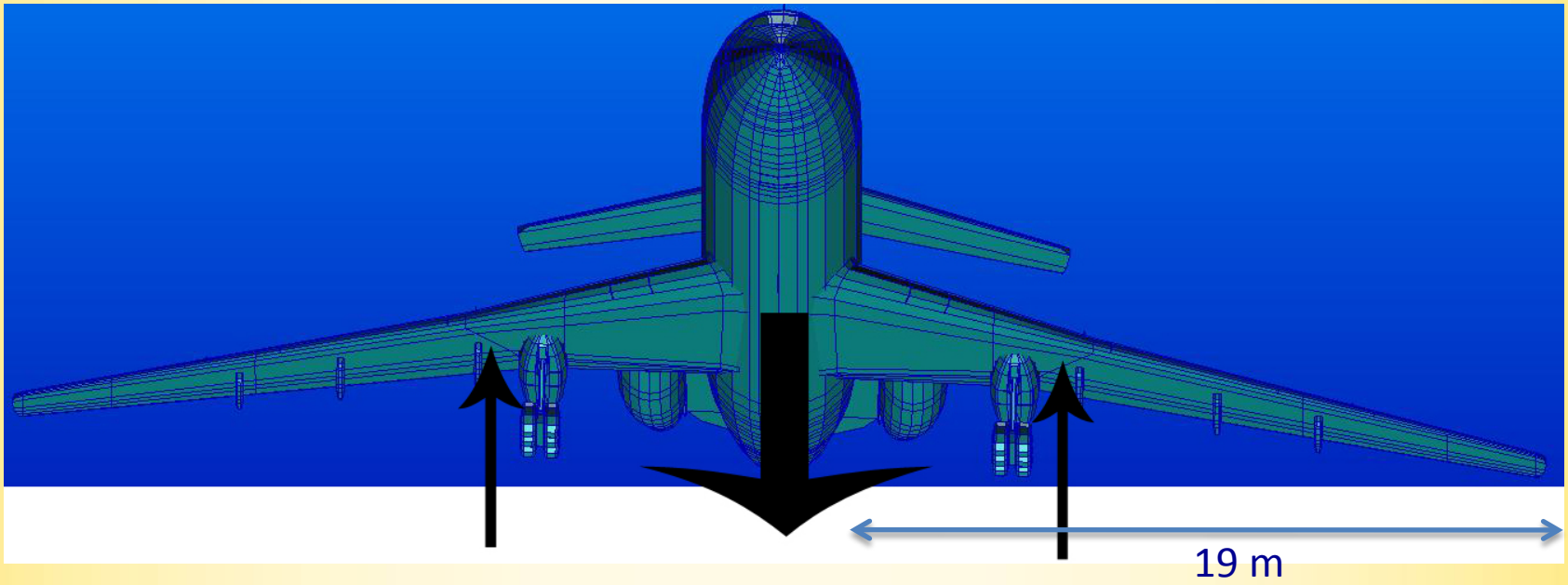


Рис. 2.31. Схема крыла:

1—носовая часть (носок) центроплана; 2—внутренний предкрылок; 3—кессон центроплана; 4—средний предкрылок; 5—кессон ОЧК; 6—внешний предкрылок; 7—концевой обтекатель; 8—элерон; 9—аэродинамическая перегородка; 10—элерон-интерцептор; 11—хвостовая часть ОЧК;12—внешний закрылок; 13—средний интерцептор; 14—внутренний интерцептор; 15—внутренний закрылок; 16—хвостовая часть центроплана

Plane in equillibrium



- Wing of the plane are the strongest part of the plane structure.

Birch material parameters

- http://www.matbase.com/material/wood/class4-5-10-years/birch/properties

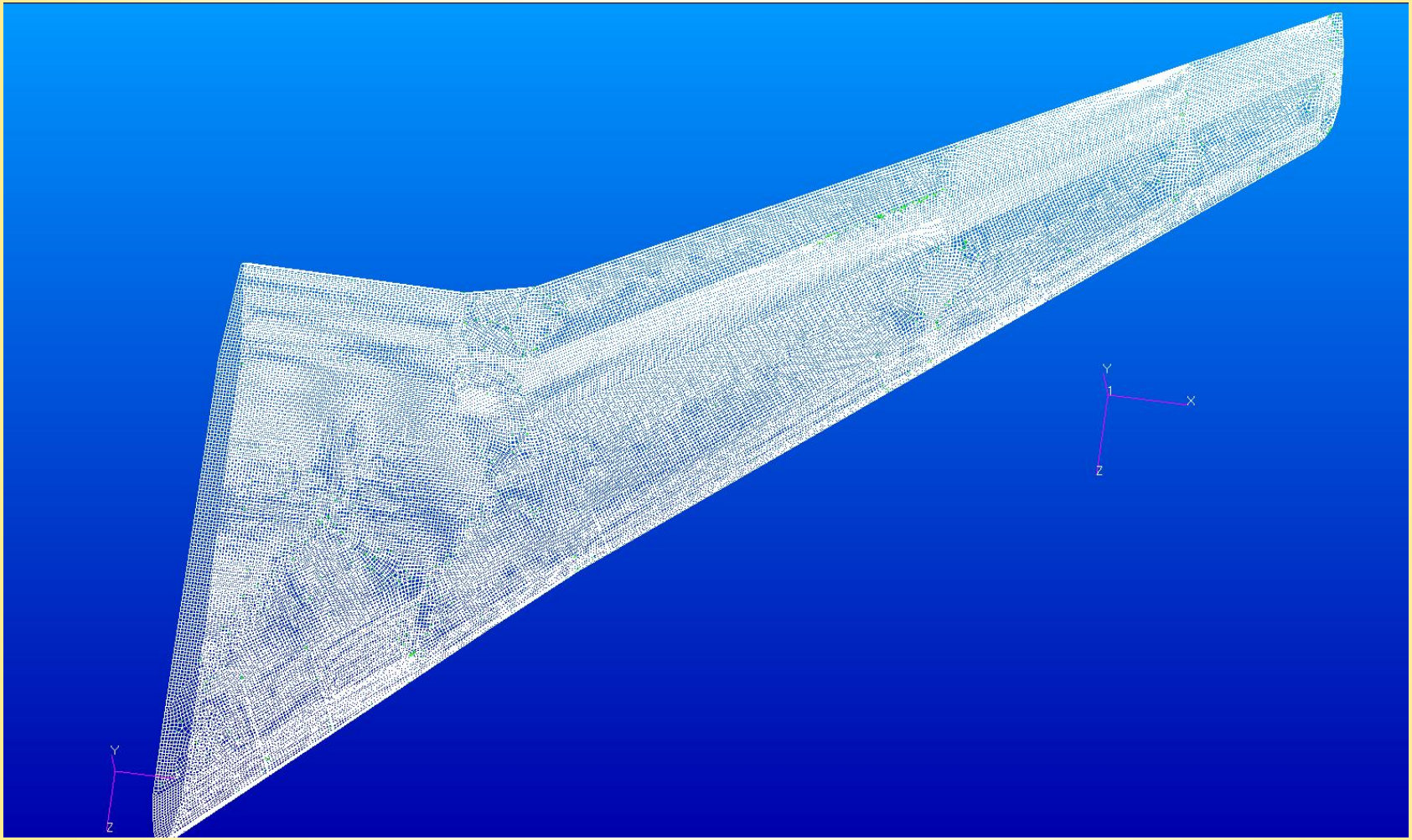
Density(Kg/m^3)	Longitudinal modulus, Eb(Pa)	Radius Modulus, Ea(Pa)	Transverse Modulus, Ec (Pa)	Poisson Ratio, vba	Poisson Ratio, vca	Poisson Ratio, vcb
550	1.03E+10	5.15E+8	8.034E+8	0.451	0.697	0.043
Shear Modulus, Gab (Pa)	Shear Modulus, Gbc (Pa)	Shear Modulus, Gca (Pa)	Maximum Effective Strain			
7.04E+8	7.622E+8	1.751E+8	0.05			

Aluminum Material Parameters Tu-154

- Parameters of Aluminum Alloys taken from: http://www.splav.kharkov.com/en/

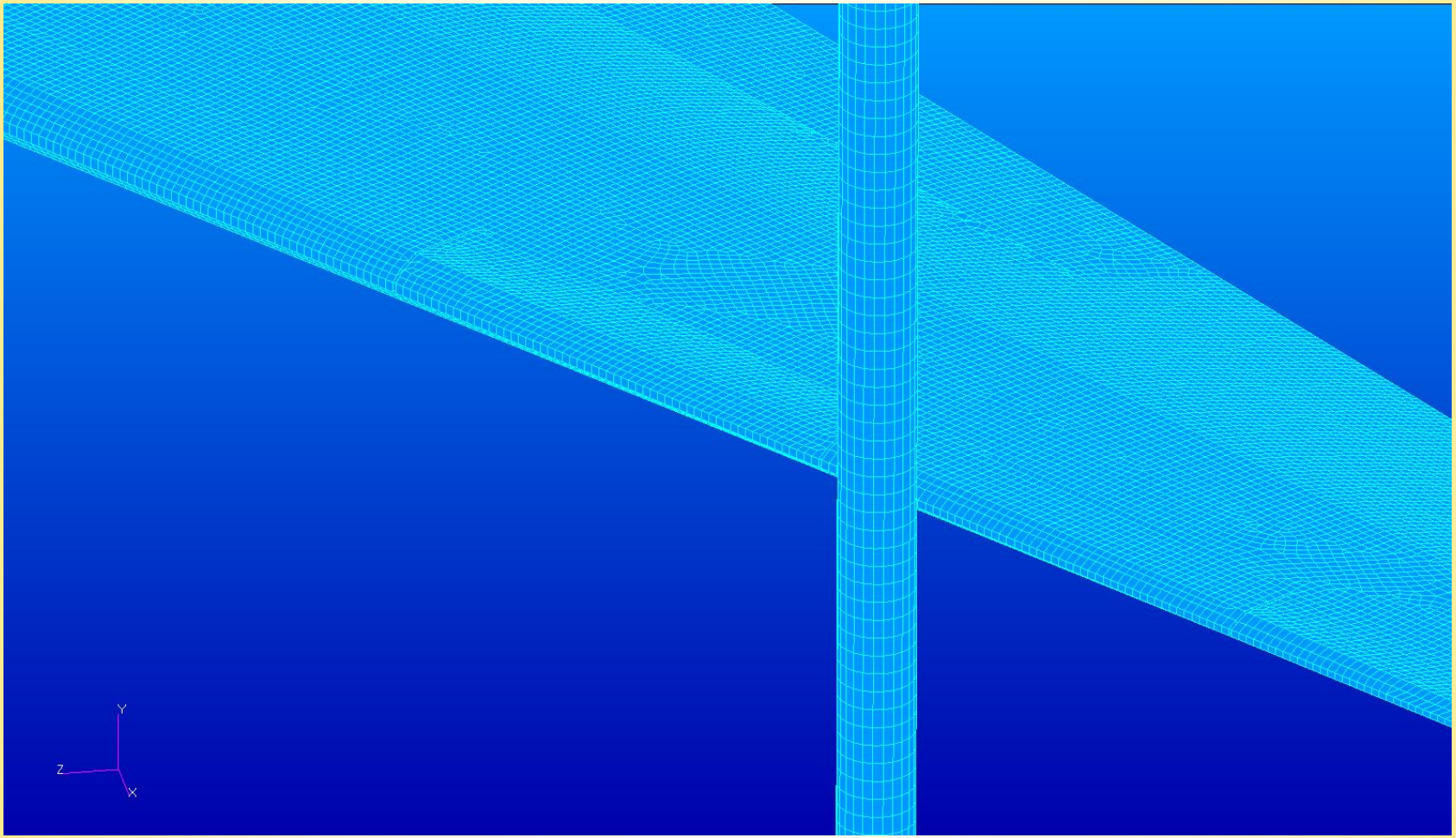
Density(Kg/m^3)	Young's modulus, E(Pa)	Yield Stress(Pa)	Tangent Modulus, Ec (Pa)	Poisson Ratio, v	Failure Strain
2850	7.4E+10	4.44E+8	5.738E+8	0.33	0.14

FEM Model of the Wing



Accuracy of the results depend on the size of the elements used.

Close-up of the wing and tree area



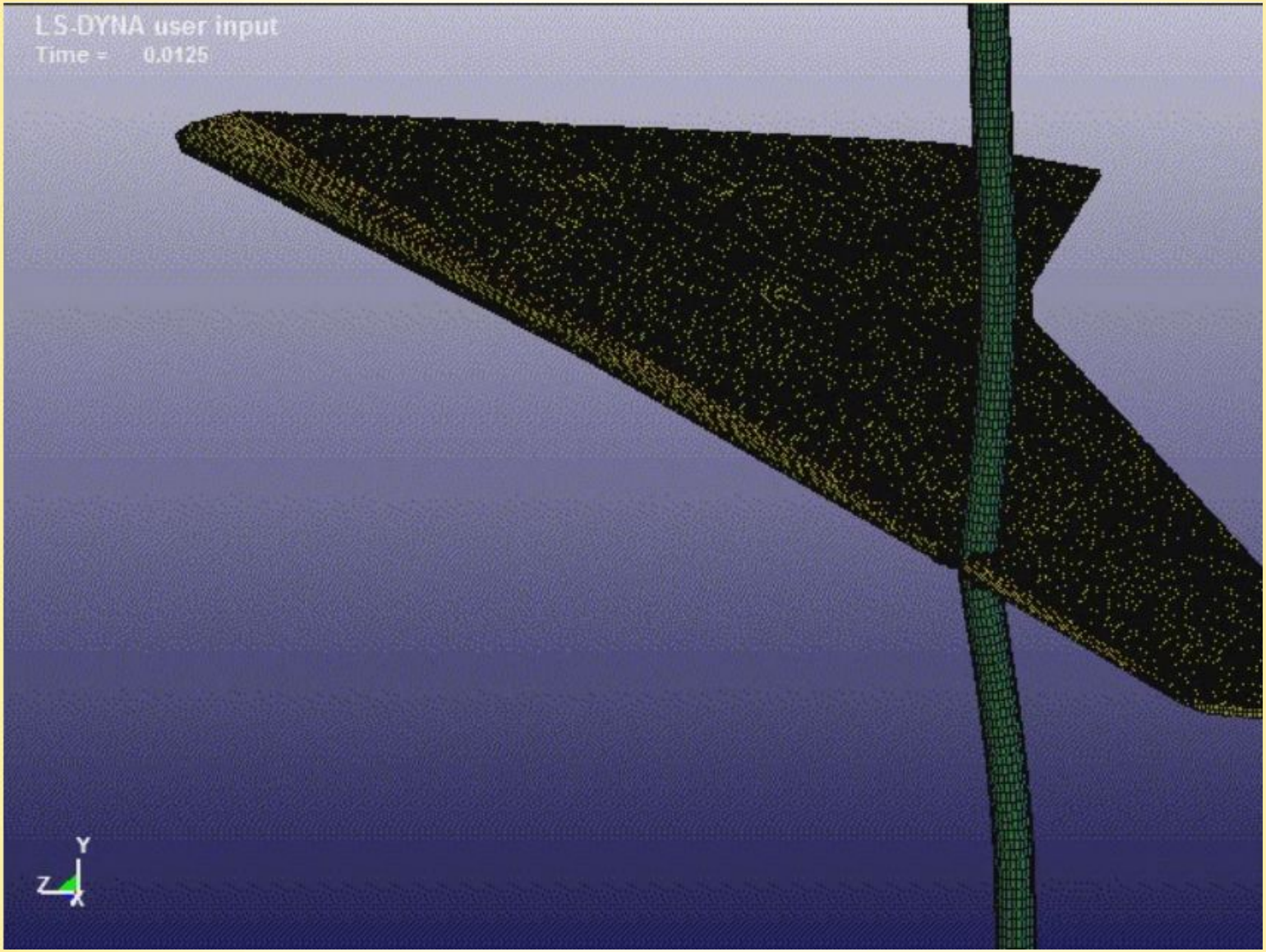
Computer System Used

- Machines with parallel processors
- Explicit FEM
  - Time step of the order 10^{-9} sec.
- Total real time to run each case from7-10 days.

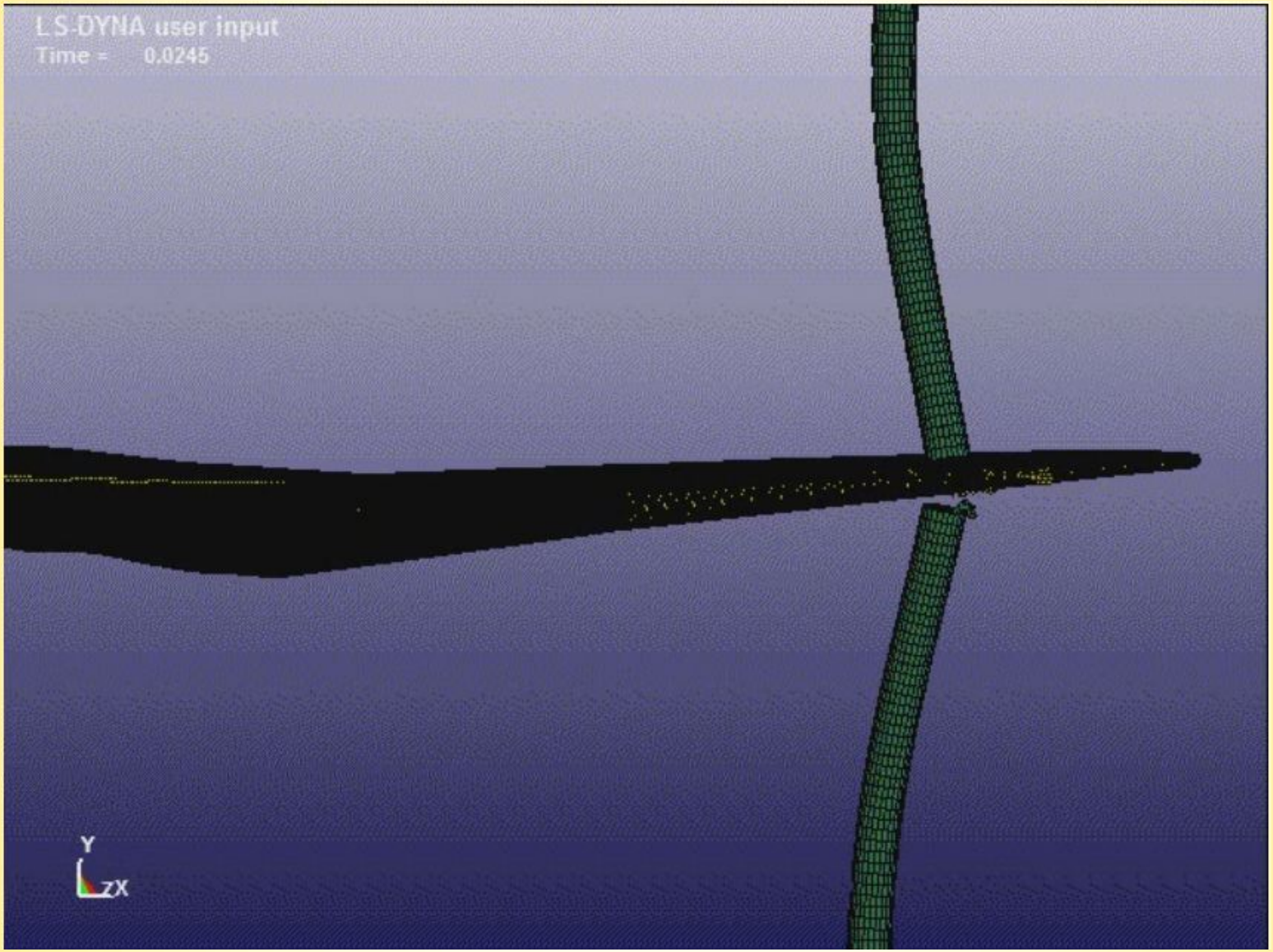
Results

- Simulations demonstrated using LsPost
  - –Wing crashing to the tree,
  - –Local tree behavior,
  - –Local wing damage

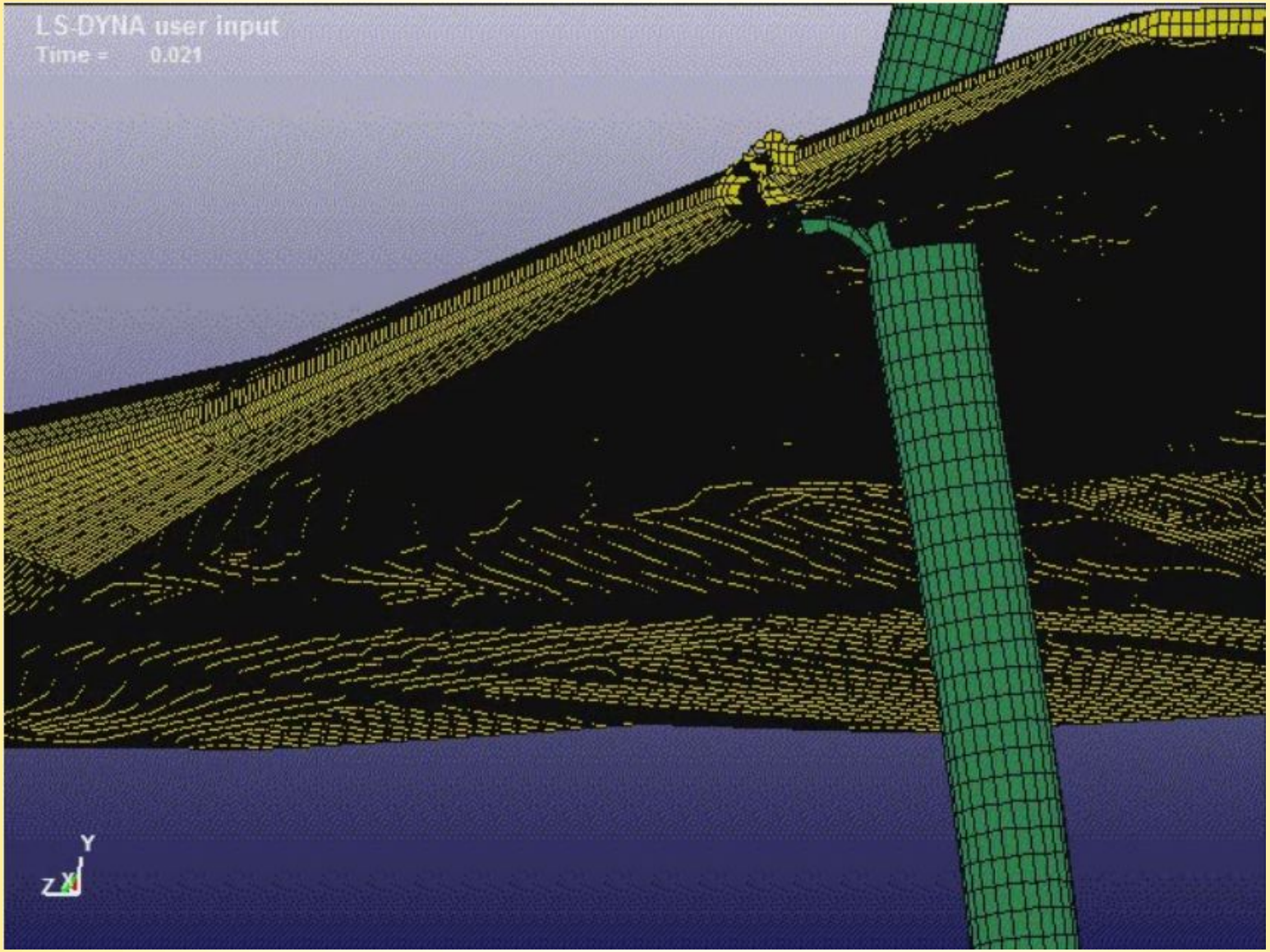
Simulation 1



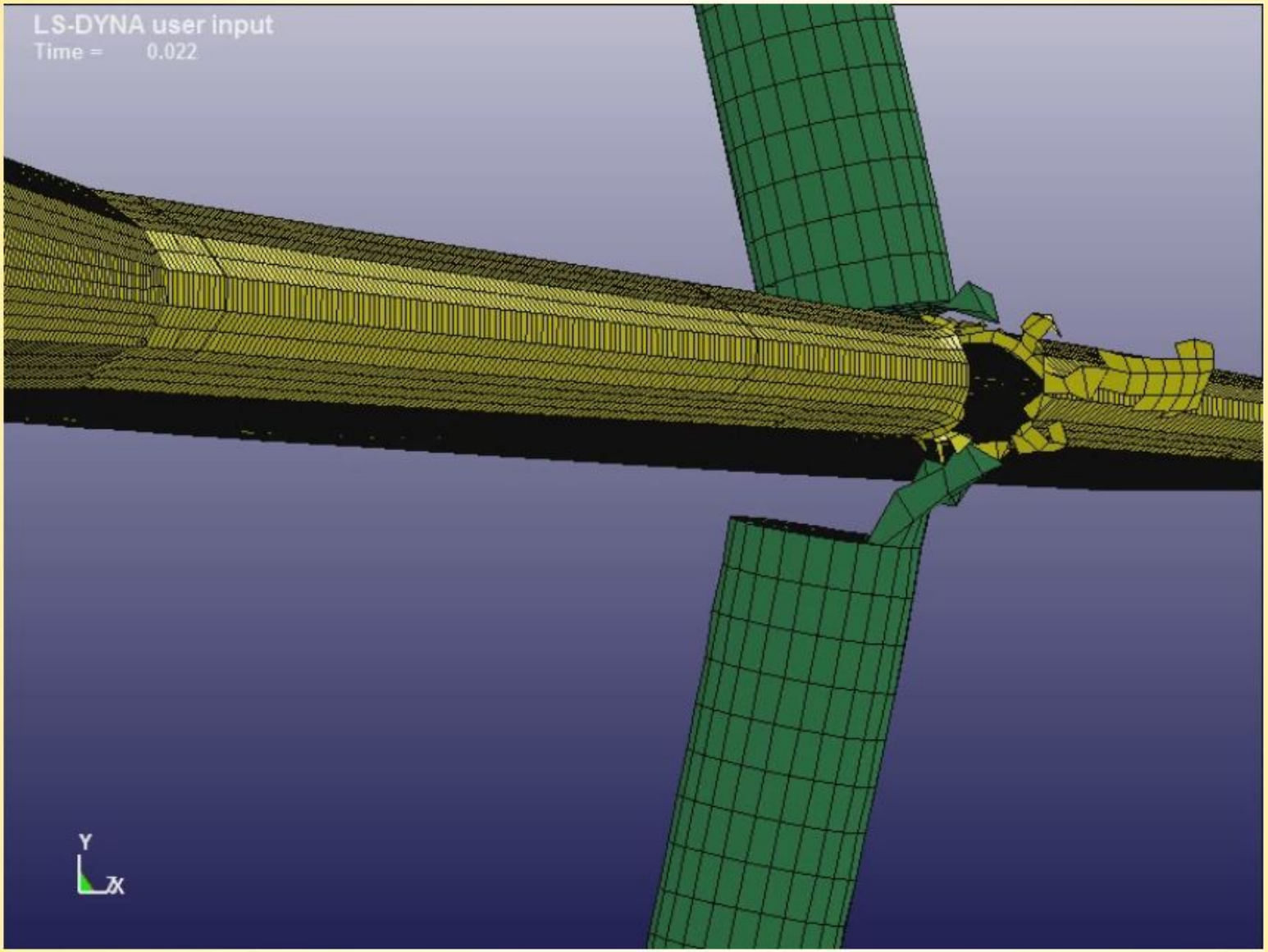
Simulation 2



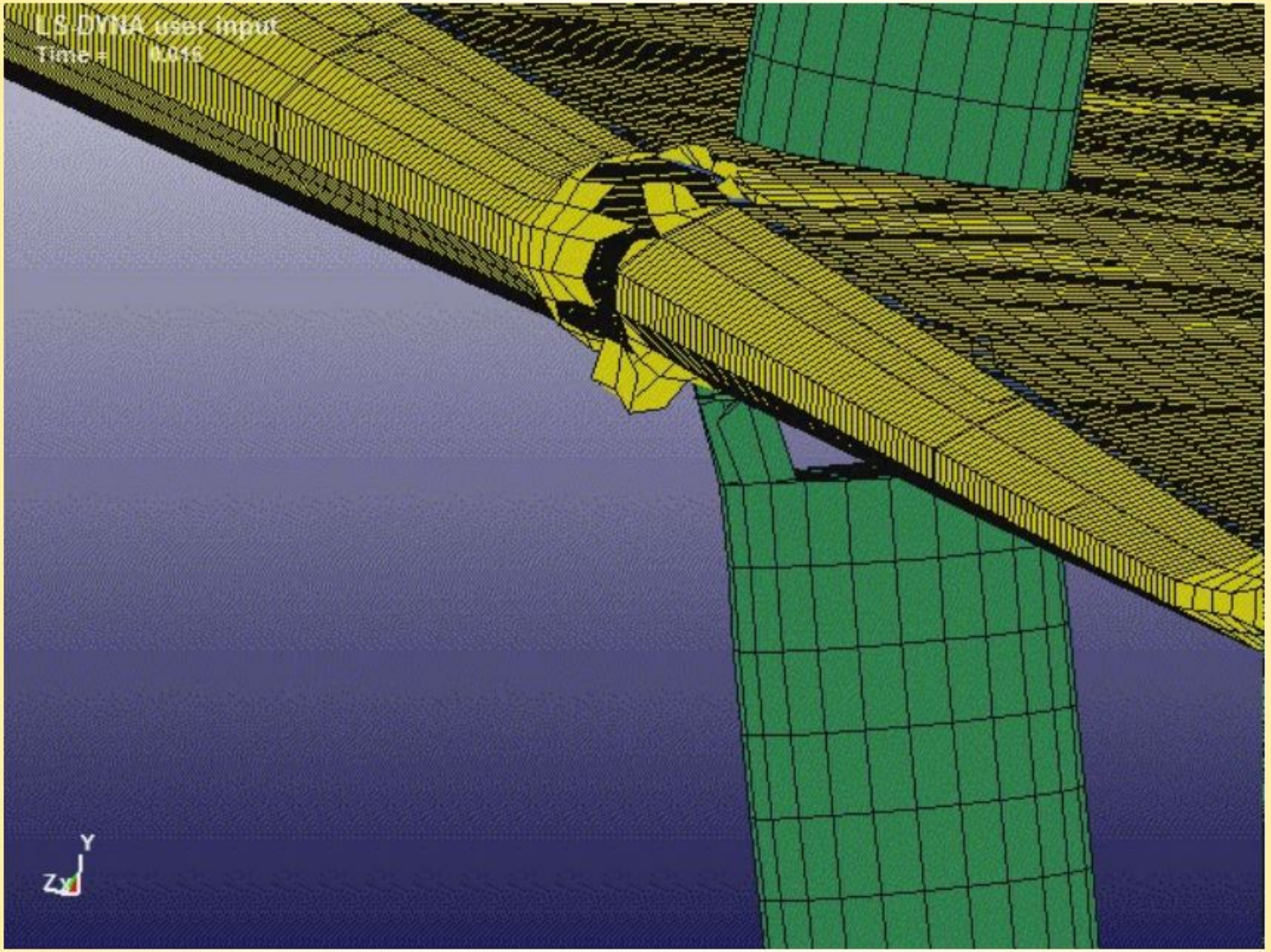
Simulation 3



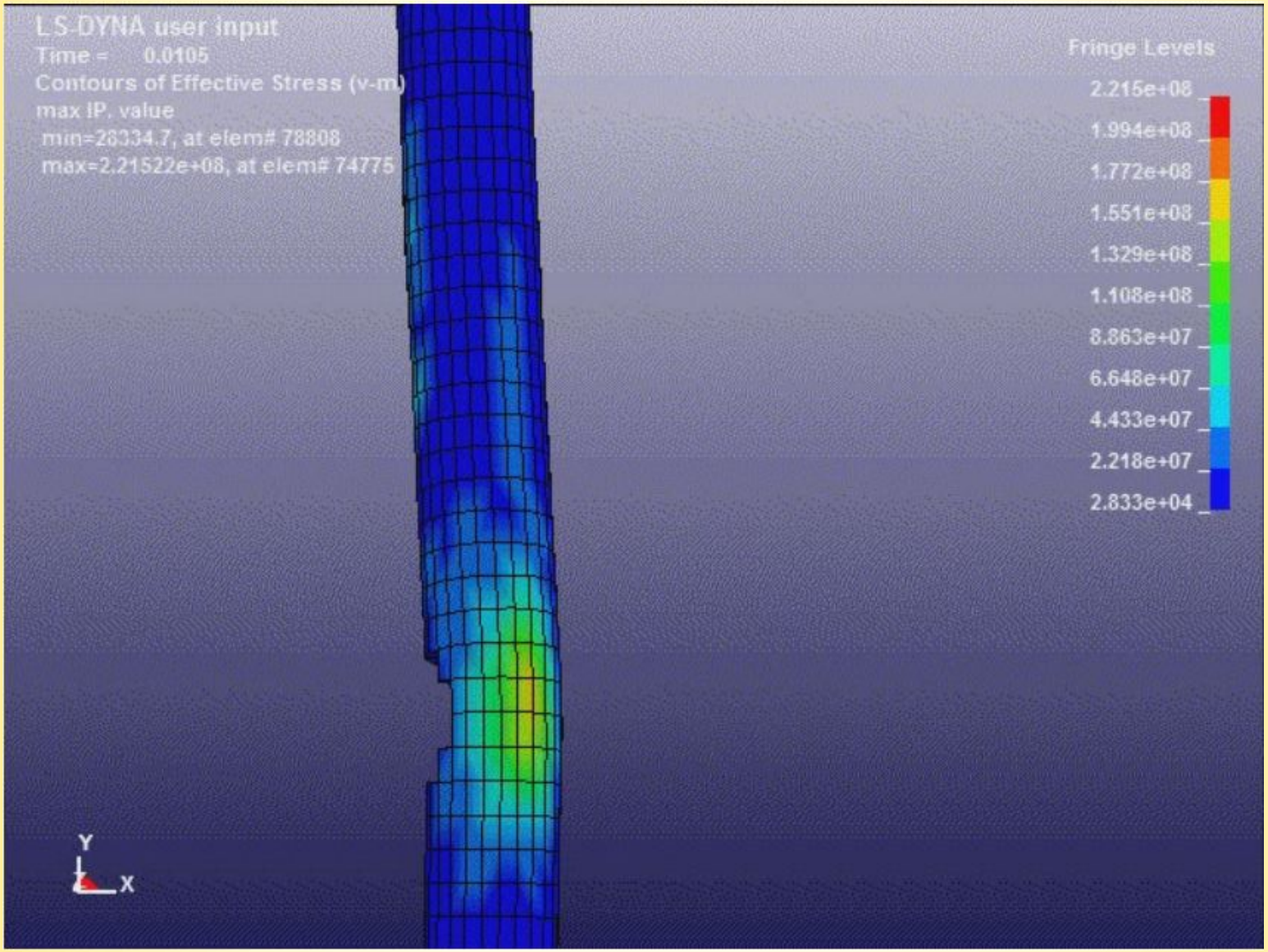
Simulation 4



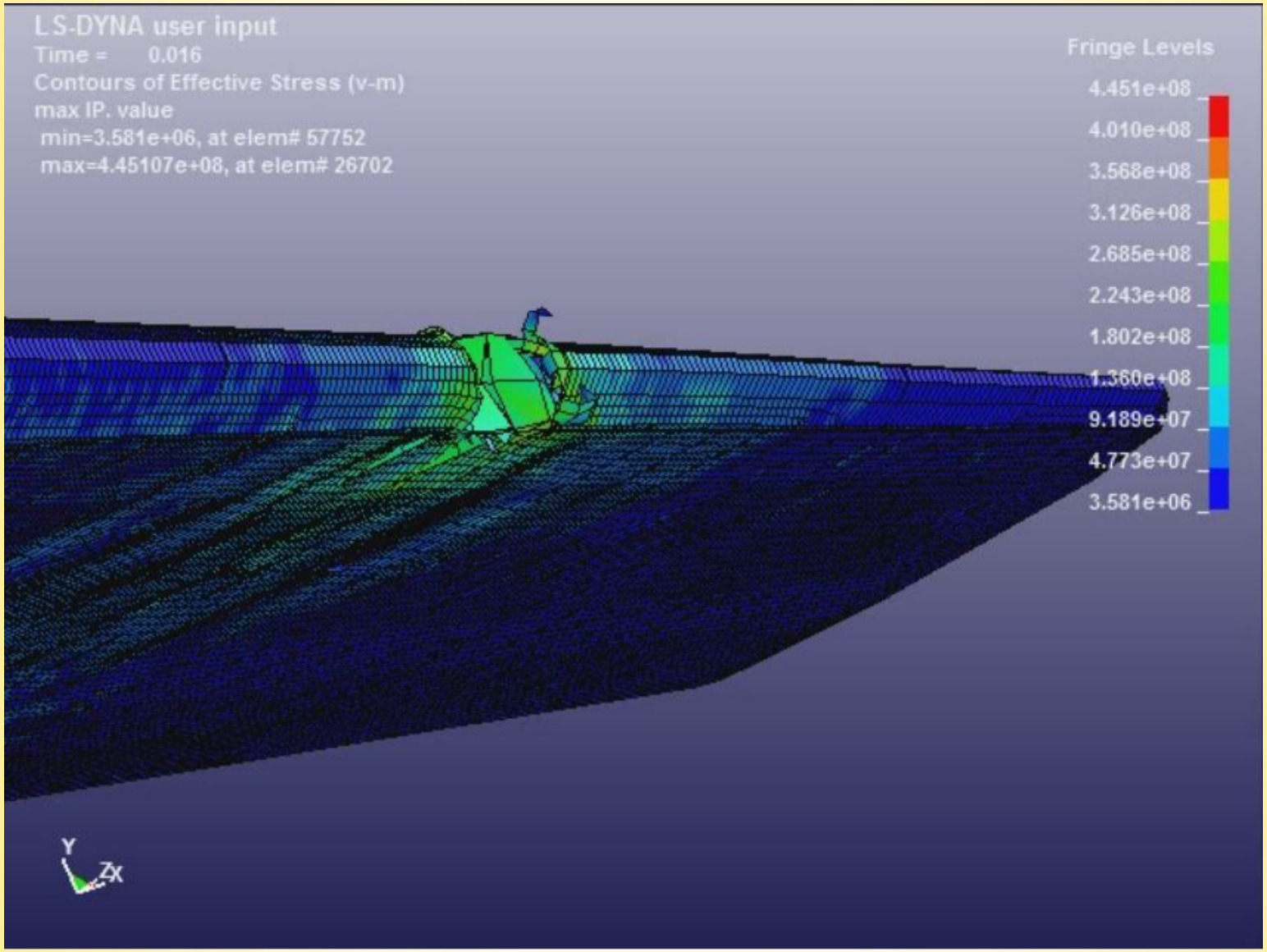
Simulation 5



Birch simulation



Wing Simulation



Conclusions

- Based on the parameters provided in the report of Minister Jerzy Miller, the model shows that the wing of the Tu-154M plane cuts through the birch for every analyzed scenario.
- The damage to the wing is localized on the edge, does not impact the lift surface of the wing, thus should not significantly reduce the ability of the plane to fly.