

# NASA Rotor 37

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This page contains various informations associated to one of the rotor 37 blade model used in LAVA publications.

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## Original model

- Original technical report <sup>[1]</sup>:

```
@TechReport{reid1978design,  
author      = {Reid, L. and Moore, R. D.},  
title       = {Design and overall performance of four highly loaded, high  
speed inlet stages for an advanced high-pressure-ratio core compressor},  
institution = {NASA Lewis Research Center Cleveland, OH, United States},  
note        = {NASA-TP-1337, url~:  
\url{https://ntrs.nasa.gov/citations/19780025165}, 1978 (accessed  
2020-10-29)}}}
```

- Pictures :



Fig1. <https://catalog.archives.gov/id/17468361>



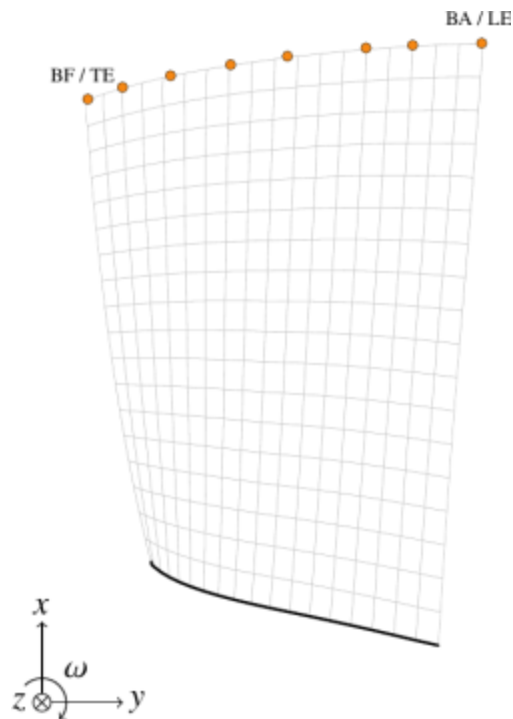
Fig2. <https://catalog.archives.gov/id/17468389>

```
@Misc{huebler1977records,  
author   = {Huebler, D.},  
title    = {Rotor 37 and stator 37 assembly. {R}ecords of the {N}ational  
{A}eronautics and {S}pace {A}dministration, 1903 - 2006. {P}hotographs  
relating to agency activities, facilities and personnel, 1973 - 2013},  
note     =  
{\href{https://catalog.archives.gov/id/17468361}{https://catalog.archives.  
gov/id/17468361}}, 1977 (accessed 2020-10-29)}, % for Fig. 1
```

note =  
{\href{https://catalog.archives.gov/id/17468389}{https://catalog.archives.gov/id/17468389}}, 1977 (accessed 2020-10-29)}, % for Fig. 2}

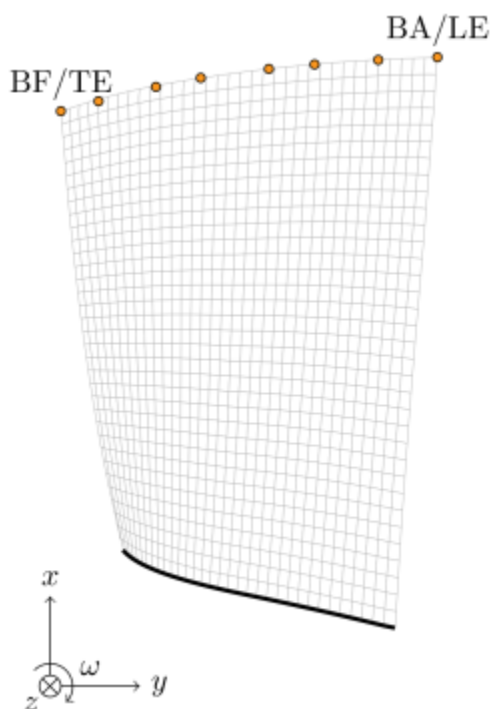
## Finite element mesh

- Number of nodes: 5745
- Total number of elements: 1800
- Number of degrees of freedom: 16524
- Element type: quadratic pentahedron



finite element mesh overview (coarse mesh)

- Number of nodes: 20657
- Total number of elements: 6664
- Number of degrees of freedom: 60588
- Element type: quadratic pentahedron



[finite element mesh overview \(refined mesh\)](#) -

[LaTeX source files](#)

## Material properties

- Rotor 37 is made of a 200-grade maraging steel <sup>[1]</sup>
- Considered properties : 18-Ni 200-maraging alloy <sup>[2] [3]</sup>:
  1. Young's modulus  $E = 180$  GPa
  2. density  $\rho = 8000$  kg/m<sup>3</sup>
  3. Poisson's ratio  $\nu = 0.3$
  4. yield stress  $\sigma_Y = 1.38$  GPa (200 000 psi)
- First three predicted natural frequencies (with clamped root) for the coarse mesh:
  1. 1B: 5272.3 rad/s / 839.1 Hz
  2. 1T: 15760.5 rad/s / 2508.4 Hz
  3. 2B: 19071.3 rad/s / 3035.3 Hz
- First three predicted natural frequencies (with clamped root) for the refined mesh:
  1. 1B: 5368.7 rad/s / 838.5 Hz
  2. 1T: 15754.7 rad/s / 2507.4 Hz
  3. 2B: 19032.9 rad/s / 3029.2 Hz

## Featured articles from the LAVA

- *The harmonic balance method with arc-length continuation in blade-tip/casing contact problems* <sup>[2]</sup>  
BibTex  
x

```
@Article{colaitis2021harmonic,  
  author = {Cola\{"i}tis, Y. and Batailly, A},
```

```

title    = {{The harmonic balance method with arc-length continuation in
blade-tip/casing contact problems}},
journal  = {J. Sound Vib.},
year     = {2021},
volume   = {502},
pages    = {116070},
issn     = {0022-460X},
note     = {\href{https://doi.org/10.1016/j.jsv.2021.116070}{doi~:
10.1016/j.jsv.2021.116070} -
\href{https://hal.archives-ouvertes.fr/hal-03163560}{oai: hal-03163560}},
abstract = {This article presents a Harmonic Balance Method-based
numerical strategy to provide a qualitative numerical characterization of
a compressor blade's dynamics when structural contacts occur with the
surrounding casing. The mitigation of the Gibbs phenomenon follows a two-
pronged approach: (1) a regularization of the unilateral contact law and
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filtering technique. In order to validate the proposed approach, it is
first applied to an academic cantilever rod undergoing unilateral contact
constraints. An in-depth comparative analysis of the obtained results—with
an emphasis on displacements, contact forces and velocities—with respect
to a time integration-based reference numerical strategy underlines the
relevance and accuracy of the proposed methodology. The latter is then
applied to the vibration analysis of an industrial compressor blade: NASA
rotor 37. For a given contact configuration, obtained results are
thoroughly compared to those obtained with a previously published time
integration-based numerical strategy with a distinct contact treatment
algorithm. Particular attention is paid to demonstrate the accuracy of the
methodology for the prediction of displacements, contact forces,
velocities as well as stress fields within the blade. Notably, it is
evidenced that the proposed methodology, contrary to the reference time
integration-based numerical strategy, is able to capture the exact
location of the blade's nonlinear resonance.}}

```

- *Blade/casing rubbing interactions in aircraft engines: Numerical benchmark and design guidelines based on NASA rotor 37* <sup>[3]</sup> BibTex

x

```

@Article{piollet2019blade,
author   = {Piollet, E. and Nyssen, F. and Batailly, A.},
title    = {Blade/casing rubbing interactions in aircraft engines:
Numerical benchmark and design guidelines based on NASA rotor 37},
journal  = {J. Sound Vib.},
year     = {2019},
volume   = {460},
pages    = {114878},
issn     = {0022-460X},
note     = {\href{https://doi.org/10.1016/j.jsv.2019.114878}{doi~:

```

```
10.1016/j.jsv.2019.114878} -  
\href{https://hal.archives-ouvertes.fr/hal-02281666}{oai: hal-02281666}},  
  abstract = {In order to improve the efficiency of aircraft engines, the  
reduction of clearances between blade tips and their surrounding casing is  
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reduction increases the risk of blade tip/casing contact interactions  
under nominal operating conditions. Designers need tools to accurately  
predict subsequent nonlinear vibrations. Engineers and researchers have  
developed a variety of sophisticated numerical models to predict blades'  
responses. These models are related to distinct frameworks (time/frequency  
domain) and various solution algorithms (explicit/implicit time  
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calls for comparative analyses. However, published results are often  
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simplified academic models, full scale models are needed to predict  
complex interactions in a realistic manner. In this context, this paper  
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3D finite element model based on the open NASA rotor 37 compressor blade  
to facilitate reproducibility and collaboration across the research  
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industrial geometries. Based on works showing improved aerodynamic  
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lean variations are shown to have a dramatic impact on the vibration  
response: the backward sweep results in an increased blade's robustness to  
contact events and the full forward chordwise sweep in a reduced  
robustness, while the forward lean leads to a robustness similar to the  
reference blade.}}
```

Cette page contient diverses informations associées à l'un des modèles de l'aube NASA rotor 37 utilisé

dans les publications du LAVA.

Fichiers téléchargeables

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**Libre accès**

[lien vers le projet Git](#)

## Modèle original

- Rapport technique original <sup>[1]</sup>:

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- Photographies :



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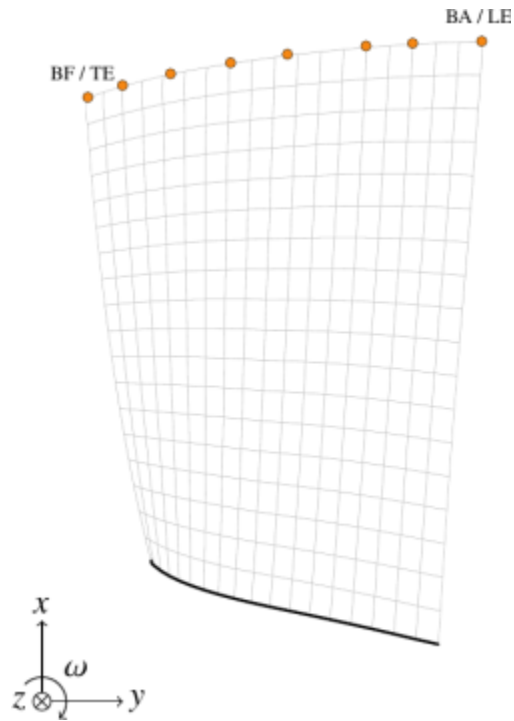


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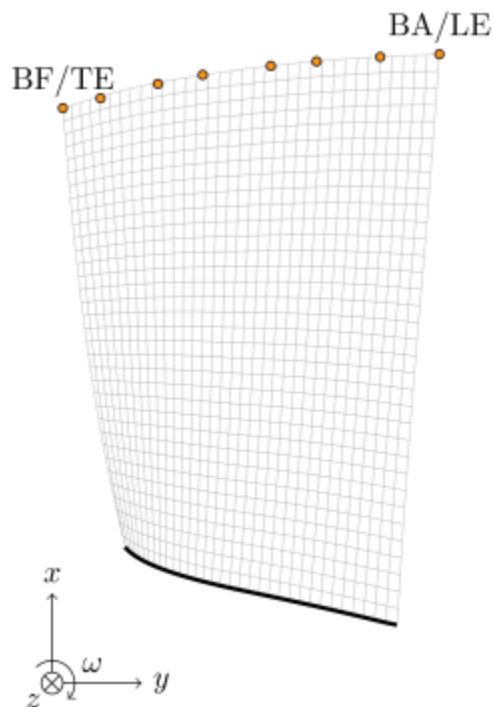
## Maillage éléments finis

- Nombre de noeuds : 5745
- Nombre total d'éléments : 1800
- Nombre de degrés de liberté : 16524
- Type d'élément : pentaèdre quadratique



aperçu du maillage éléments finis (maillage grossier)

- Nombre de noeuds : 20657
- Nombre total d'éléments : 6664
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- Type d'élément : pentaèdre quadratique



aperçu du maillage éléments finis (maillage fin) -

sources LaTeX

## Propriétés matériau

- Le matériau du rotor 37 est un alliage à base de nickel : un acier maraging de grade 200 <sup>[1]</sup>
- Propriétés considérées : alliage 18-Ni 200-maraging <sup>[2] [3]</sup>:
  1. Module d'Young  $E = 180$  GPa
  2. masse volumique  $\rho = 8000$  kg/m<sup>3</sup>
  3. coefficient de Poisson  $\nu = 0,3$
  4. limite élastique  $\sigma_Y = 1,38$  GPa (200 000 psi)
- Trois premiers modes prévus (noeuds de la base encastés) pour le maillage grossier :
  1. 1F : 5272,3 rad/s / 839,1 Hz
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## Articles du laboratoire

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BibTex  
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  author   = {Cola\{"i}tis, Y. and Batailly, A},  
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  abstract = {This article presents a Harmonic Balance Method-based  
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1. [a](#), [b](#), [c](#), [d](#) Reid. «Design and overall performance of four highly loaded, high speed inlet stages for an advanced high-pressure-ratio core compressor » 1978. p64 [pdf](#)
2. [a](#), [b](#), [c](#), [d](#) Colaitis. «The harmonic balance method with arc-length continuation in blade-tip/casing contact problems » 2021. [doi/oai](#)
3. [a](#), [b](#), [c](#), [d](#) Piollet. «Blade/casing rubbing interactions in aircraft engines: Numerical benchmark and design guidelines based on NASA rotor 37 » 2019. [doi/oai](#)

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