

# Product development in mechanical engineering with open-source software

A guide for small machine manufacturers in the  
European Union

FOSDEM 25, Brussels - 01.02.2025

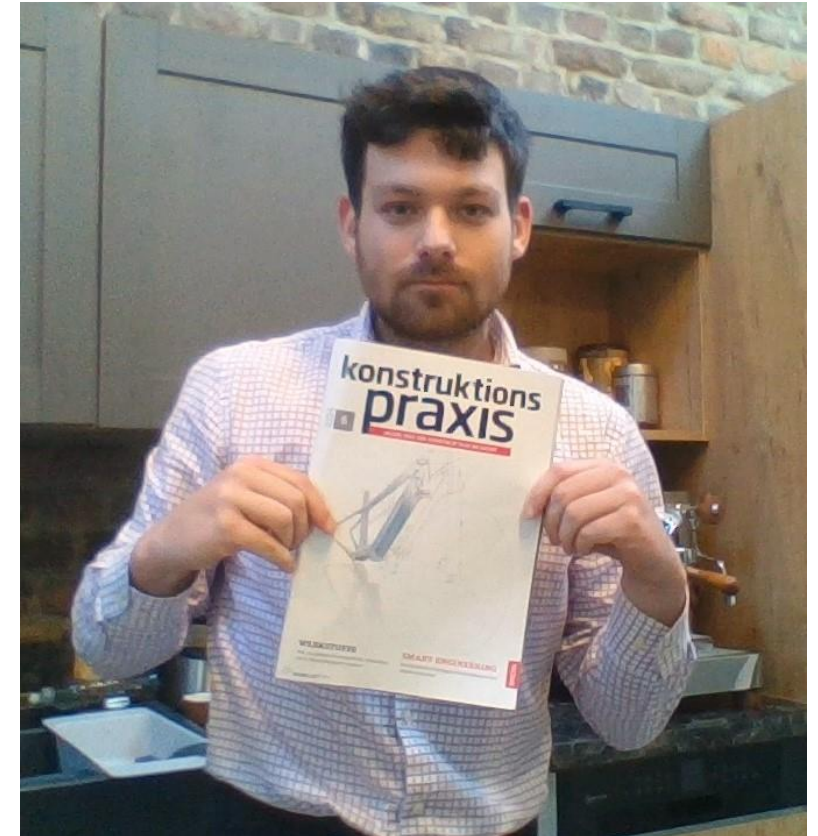
Aleksander Sadowski

**ALSADO**

# My personal story – How this talk came to be

- Passionate about becoming a machine manufacturer in Germany, mechanical engineering student
- Learned about FreeCAD, because I couldn't open my own project of a 3D printer with a heated build chamber, after my Catia V5 student license expired
- Stopping sales of my workholding fixtures, designed in FreeCAD because I learned about patents and product safety
- Learning how to work with patents and how to ensure product safety at German machine manufacturer GROB
- Helping others become machine manufacturers in the European Union

**=> Providing a guide for product development in mechanical engineering with open-source software**



# Understanding who this guide is for

## **Manufacturing start-ups**

Help makers become manufacturers by demystifying patents and product certification, lowering fear and perceived risk, which in total aids in creating innovations. Provide a free and open-source workflow blueprint for product development and bringing new products to market.

## **Established machine manufacturers**

Provide options on how to implement the steps of the product development process using open-source software.

## **FreeCAD community**

Showcase FreeCAD into context with other software and spread the word about it so that we can make it the default CAD software in the industry.



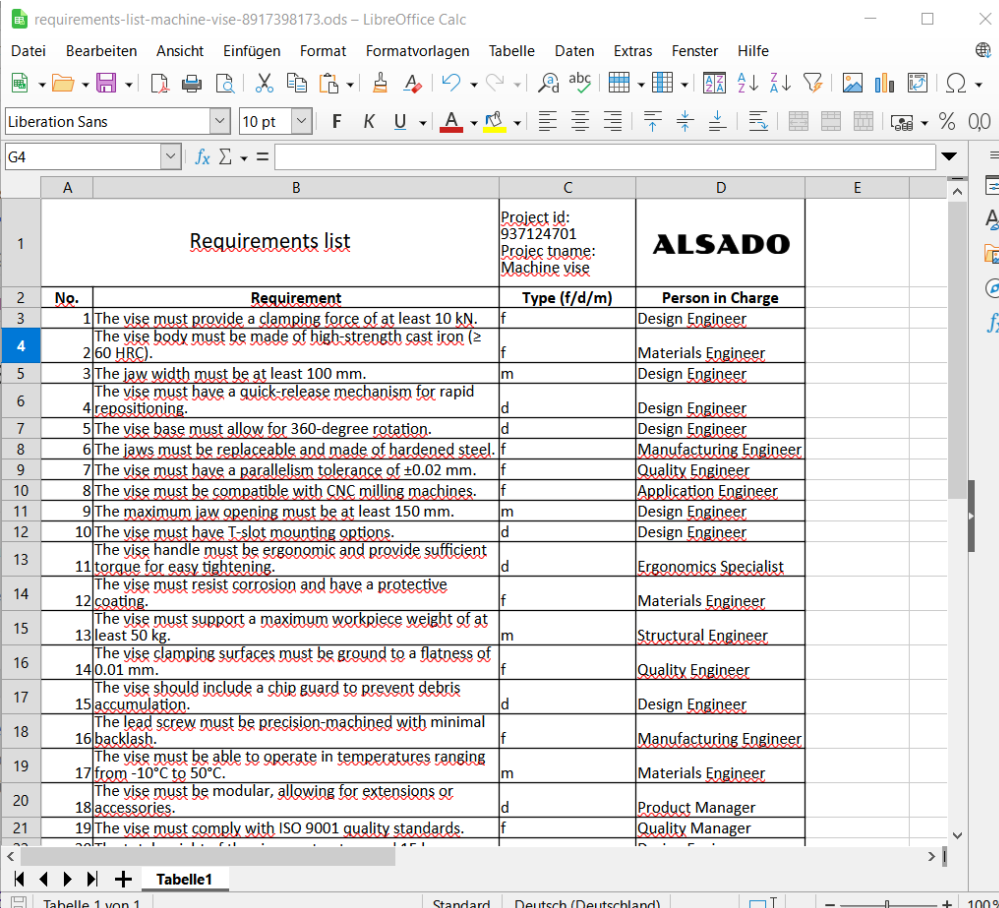
# Getting an overview of the product development process

1. Defining requirements in LibreOffice Calc
2. Finding inventions in public domain on [espacenet.com](http://espacenet.com)
3. Keeping track of inventions with LibreOffice Calc
4. Creating product concept variations using LibreOffice Calc
5. Picking a product concept using LibreOffice Calc
6. Product safety (CE), including risk assessment using LibreOffice
7. Preliminary design using LibreOffice Calc
8. Detailed design in FreeCAD
9. FEM Simulation in PrePoMax
10. On-premise product lifecycle management using Subversion
11. Alternative: Google Drive
12. Benefits of a PLM solution

# Defining requirements in LibreOffice Calc

- Requirements list keeps all project members on track with the project goal
- Is based on the research performed for the target market of the new product
- Requirements list consists of columns:
  - „No.“
  - „Requirement“
  - „Type (f/d/m)“
  - „Person in charge“

**Software used:** LibreOffice Calc



requirements-list-machine-vise-8917398173.ods - LibreOffice Calc

Datei Bearbeiten Ansicht Einfügen Format Formatvorlagen Tabelle Daten Extras Fenster Hilfe

Liberation Sans 10 pt F K U A

G4

|    | A   | B  | C   | D                      | E |
|----|-----|--|---|------------------------|---|
| 1  |     | Requirements list  | Project id:<br>937124701<br>Project name:<br>Machine vise | <b>ALSADO</b>          |   |
| 2  | No. | Requirement  | Type (f/d/m)  | Person in Charge       |   |
| 3  | 1   | The vise must provide a clamping force of at least 10 kN.                            | f   | Design Engineer        |   |
| 4  | 2   | The vise body must be made of high-strength cast iron (≥ 260 HRC).                   | f   | Materials Engineer     |   |
| 5  | 3   | The jaw width must be at least 100 mm.   | m   | Design Engineer        |   |
| 6  | 4   | The vise must have a quick-release mechanism for rapid repositioning.                | d   | Design Engineer        |   |
| 7  | 5   | The vise base must allow for 360-degree rotation.                                    | d   | Design Engineer        |   |
| 8  | 6   | The jaws must be replaceable and made of hardened steel.                             | f   | Manufacturing Engineer |   |
| 9  | 7   | The vise must have a parallelism tolerance of ±0.02 mm.                              | f   | Quality Engineer       |   |
| 10 | 8   | The vise must be compatible with CNC milling machines.                               | f   | Application Engineer   |   |
| 11 | 9   | The maximum jaw opening must be at least 150 mm.                                     | m   | Design Engineer        |   |
| 12 | 10  | The vise must have T-slot mounting options.  | d   | Design Engineer        |   |
| 13 | 11  | The vise handle must be ergonomic and provide sufficient torque for easy tightening. | d   | Ergonomics Specialist  |   |
| 14 | 12  | The vise must resist corrosion and have a protective coating.                        | f   | Materials Engineer     |   |
| 15 | 13  | The vise must support a maximum workpiece weight of at least 50 kg.                  | m   | Structural Engineer    |   |
| 16 | 14  | The vise clamping surfaces must be ground to a flatness of 0.01 mm.                  | f   | Quality Engineer       |   |
| 17 | 15  | The vise should include a chip guard to prevent debris accumulation.                 | d   | Design Engineer        |   |
| 18 | 16  | The lead screw must be precision-machined with minimal backlash.                     | f   | Manufacturing Engineer |   |
| 19 | 17  | The vise must be able to operate in temperatures ranging from -10°C to 50°C.         | m   | Materials Engineer     |   |
| 20 | 18  | The vise must be modular, allowing for extensions or accessories.                    | d   | Product Manager        |   |
| 21 | 19  | The vise must comply with ISO 9001 quality standards.                                | f   | Quality Manager        |   |

Tabelle1

Tabelle 1 von 1

Standard Deutsch (Deutschland)

100%

# Finding inventions in public domain on [espacenet.com](https://www.espacenet.com)

- Form a search query that limits the 150M available patent documents to 200 results by using filters:
  - IPC/ CPC class from initial search
  - Use Keywords from requirements
  - issue date more then 20 years back
- Find infringement-safe inventions from public domain (>20 years)
- Add suitable to „My Patents“ on [espacenet.com](http://espacenet.com) and narrow down the results from 200 to 20.

**Software used:** [www.espacenet.com](http://www.espacenet.com)

**Espacenet – Suchergebnisse**

https://worldwide.espacenet.com/patent/search/family/006854478/publication/DE9006421U1

ChatGPT Meine Ablage – Goog... The International Jour... E Espacenet – Patentklas... E Espacenet – Suche... E Espacenet – Suchege... Ask Patents

**Espacenet**  
Patentsuche

nftxt = "maschinenschraubstock" AND nftxt = "gresstel" AND p [X] [Suchen]

Amt/Sprache ▼

Mein Espacenet Hilfe Klassifikationssuche Treffer [Erweiterte Suche] [Filter] [Pop-up-Tipps] [Datenfehler melden] [Feedback]

Home > Treffer > **DE9006421U1**

## 23 Treffer gefunden

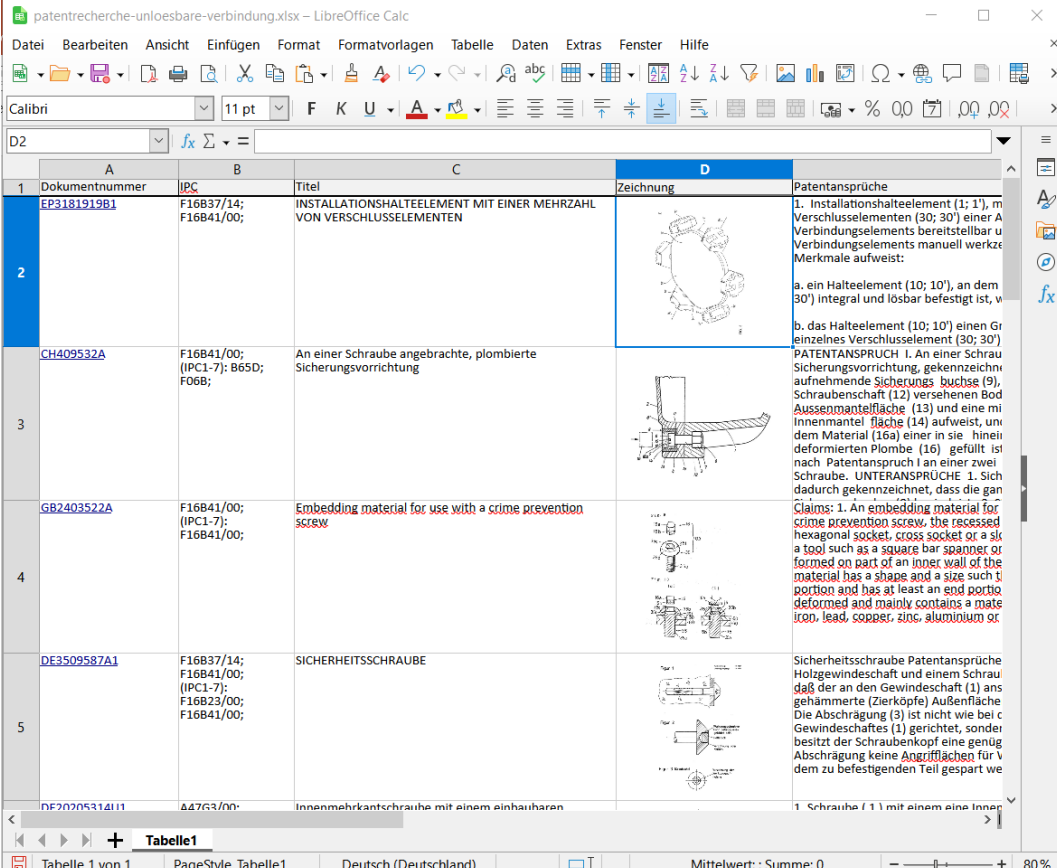
| Listenansicht | Listeninhalt   | Sortierkriterien |
|---------------|----------------|------------------|
| Nur Text ▼    | Alle Treffer ▼ | Relevanz ▼       |

- (0 Patente ausgewählt) **23 Dokument(e) angezeigt**  
weist ein an einem beweglichen Spannteil derseiden abgestütztes, hohes Gehäuse (1) auf, durch welches eine
- 12. Kein Titel verfügbar**  
**DE9006421U1 • 1991-10-02 • GRESSEL AG, AADO...**  
**Früheste Priorität: 1990-06-07 • Früheste Veröffentlichung: 1991-10-02**  
Keine Zusammenfassung verfügbar
- 13. Spannpratze.**  
**EP0325738A2 (A3,B1) • 1989-08-02 • GRESSEL AG**  
**Früheste Priorität: 1988-01-26 • Früheste Veröffentlichung: 1989-08-02**  
Eine Spannpratze (1) zum Aufspannen von Schraubstöcken (S) auf Maschinentischen (M) weist eine im wesentlichen rechteckige, ebene Spannlasche (2) mit einem sich in ihrer
- 14. Kein Titel verfügbar**  
**DE9204016U1 • 1993-07-22 • GRESSEL AG, AADO...**

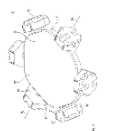
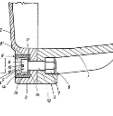
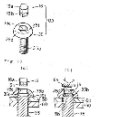
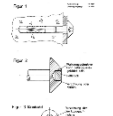
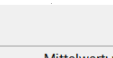
# Keeping track of inventions with LibreOffice Calc

- Patent document list lets you keep an overview of all suitable inventions for your product
- List 20 most suitable documents from patent search on espacenet.com with:
  - Document number as link to espacenet.com
  - Title
  - IPC/ CPC
  - Representative drawing
  - First claim or all independent claims

**Software used:** LibreOffice Calc



The screenshot shows a LibreOffice Calc spreadsheet titled 'patentrecherche-unloesbare-verbindung.xlsx'. The spreadsheet contains a table with 5 rows of patent data. The columns are: A (Dokumentnummer), B (IPC), C (Titel), D (Zeichnung), and E (Patentansprüche). The first row is highlighted in blue. The second row is highlighted in grey. The third row is highlighted in blue. The fourth row is highlighted in grey. The fifth row is highlighted in blue. The table is titled 'Tabelle1' and is located on 'Seite 1 von 1'.

|   | A                            | B   | C   | D   | E  |
|---|------------------------------|---|---|---|--|
|   | Dokumentnummer               | IPC   | Titel   | Zeichnung   | Patentansprüche  |
| 1 | <a href="#">EP3181919B1</a>  | F16B37/14;<br>F16B41/00;  | INSTALLATIONSHALTELEMENT MIT EINER MEHRZAHL VON VERSCHLUSSELEMENTEN |    | 1. Installationshaltelement (1; 1'), m Verschlusselementen (30; 30') einer A Verbindungselements bereitstellbar u Verbindungselements manuell werkze Merkmale aufweist:<br>a. ein Halteelement (10; 10'), an dem 30') integral und lösbar befestigt ist, v<br>b. das Halteelement (10; 10') einen Gr einzelnes Verschlusselement (30; 30')   |
| 2 |                              |   |   |   |  |
| 3 | <a href="#">CH409532A</a>    | F16B41/00;<br>(IPC1-7): B65D;<br>F06B;                            | An einer Schraube angebrachte, plombierte Sicherungsvorrichtung     |    | PATENTANSPRÜCHE 1. An einer Schrau Sicherungsvorrichtung, gekennzeichnet durch aufnehmende Sicherungs buchse (9), Schraubenschaft (12) versehenen Bod Aussemantelfläche (13) und eine mi Innenmantelfläche (14) aufweist, um dem Material (16a) einer in sie hinein deformierten Plombe (16) gefüllt ist nach Patentanspruch 1 an einer zwei Schraube. UNTERANSPRÜCHE 1. Sich dadurch gekennzeichnet, dass die gan |
| 4 | <a href="#">GB2403522A</a>   | F16B41/00;<br>(IPC1-7):<br>F16B41/00;                             | Embedding material for use with a crime prevention screw            |   | Claims: 1. An embedding material for crime prevention screw, the recessed hexagonal socket, cross socket or a sl a tool such as a square bar spanner or formed on part of an inner wall of the material has a shape and a size such b portion and has at least an end portio deformed and mainly contains a mate iron, lead, copper, zinc, aluminium or  |
| 5 | <a href="#">DE3509587A1</a>  | F16B37/14;<br>F16B41/00;<br>(IPC1-7):<br>F16B23/00;<br>F16B41/00; | SICHERHEITSSCHRAUBE   |  | Sicherheitschraube Patentansprüche Holzgewindeschafte und einem Schrau daß der an den Gewindeschafte (1) ans gehämmerte (Zierköpfe) Außenfläche Die Abschrägung (3) ist nicht wie bei c Gewindeschafte (1) gerichtet, sonder besitzt der Schraubenkopf eine genü Abschrägung keine Angriffsflächen für v dem zu befestigenden Teil gesparrt we   |
|   | <a href="#">DE20205314U1</a> | 44763/00;   | Innenmehrkantschraube mit einem einbaubaren                         |  | 1 Schraube (1) mit einem eine Innen  |

# Creating product concept variations using LibreOffice Calc

- Divide up the overall function of a product into sub-functions in the sense of a functional structure
- List all sub-functions of a product and create columns with all 20 found patents as possible solutions to each sub-function
- Name each solution-sub-function pair with 1.1, 1.2, ...
- Create product concept variations by combining different solutions as columns named „A“, „B“, „C“, ... from patent documents, one solution for each sub-function.

**Software used:** LibreOffice Calc

|  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|
| morphologischer-kasten-patente.ods - LibreOffice Calc  |  |  |  |  |  |  |  |  |  |  |  |  |
| Datei Bearbeiten Ansicht Einfügen Format Formatvorlagen Tabelle Daten Extras Fenster Hilfe   |  |  |  |  |  |  |  |  |  |  |  |  |
| Calibri 11 pt F K U A % 00 |  |  |  |  |  |  |  |  |  |  |  |  |



# Picking a product concept using LibreOffice Calc

- Evaluate each of the product concept variations based on their suitability for the requirements
- Create a sketch of the most suitable product concept on paper or as a digital mockup

**Software used:** LibreOffice Calc and LibreOffice Impress

technische-bewertung-konzeptvarianten-ods – LibreOffice Calc

Datei Bearbeiten Ansicht Einfügen Format Formatvorlagen Tabelle Daten Extras Fenster Hilfe

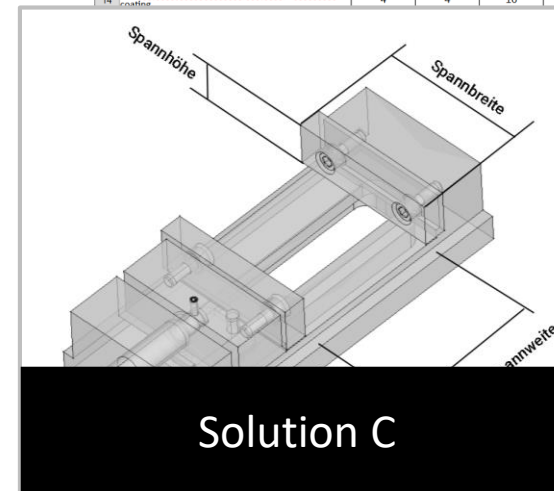
Libération Sans 10 pt F K U A

| N12 | A  | B | C    | D     | E | F     | G  | H     | I     | J     | K |
|-----|--|---|------|-------|---|-------|----|-------|-------|-------|---|
|     | Requirement  | G | A    |       | B |       | C  |       | Ideal |       |   |
|     |  |   | E    | G * E | E | G * E | E  | G * E | E     | G * E |   |
| 1   | The vise must provide a clamping force of at least 10 kN.                            | 2 | 2    | 4     | 2 | 4     | 3  | 6     | 4     | 8     |   |
| 4   | The vise body must be made of high-strength cast iron (> 60 HRC).                    | 3 | 3    | 9     | 3 | 9     | 2  | 6     | 4     | 12    |   |
| 5   | The jaw width must be at least 100 mm.   | 5 | 4    | 20    | 2 | 10    | 2  | 10    | 4     | 20    |   |
| 6   | The vise must have a quick-release mechanism for rapid repositioning.                | 2 | 2    | 4     | 2 | 4     | 2  | 4     | 4     | 8     |   |
| 7   | The vise base must allow for 360-degree rotation.                                    | 1 | 2    | 2     | 1 | 2     | 2  | 2     | 4     | 4     |   |
| 8   | The jaws must be replaceable and made of hardened steel.                             | 2 | 1    | 2     | 2 | 4     | 3  | 6     | 4     | 8     |   |
| 9   | The vise must have a parallelism tolerance of $\pm 0.02$ mm.                         | 3 | 2    | 6     | 4 | 12    | 3  | 9     | 4     | 12    |   |
| 10  | The vise must be compatible with CNC milling machines.                               | 2 | 2    | 4     | 4 | 8     | 4  | 8     | 4     | 8     |   |
| 11  | The maximum jaw opening must be at least 150 mm.                                     | 3 | 3    | 9     | 4 | 12    | 4  | 12    | 4     | 12    |   |
| 12  | The vise must have T-slot mounting options.  | 3 | 3    | 9     | 4 | 12    | 2  | 6     | 4     | 12    |   |
| 13  | The vise handle must be ergonomic and provide sufficient torque for easy tightening. | 3 | 4    | 12    | 3 | 9     | 3  | 9     | 4     | 12    |   |
| 14  | The vise must resist corrosion and have a protective coating.                        | 4 | 4    | 16    | 2 | 8     | 4  | 16    | 4     | 16    |   |
|     |  |   | 16   |       |   | 16    | 4  | 16    | 4     | 16    |   |
|     |  |   | 8    |       |   | 8     | 4  | 8     | 4     | 8     |   |
|     |  |   | 4    |       |   | 4     | 8  | 4     | 4     | 8     |   |
|     |  |   | 2    |       |   | 2     | 4  | 4     | 4     | 4     |   |
|     |  |   | 3    |       |   | 2     | 6  | 4     | 4     | 12    |   |
|     |  |   | 10   |       |   | 2     | 10 | 4     | 4     | 20    |   |
|     |  |   | 9    |       |   | 3     | 9  | 4     | 4     | 12    |   |
|     |  |   | 2    |       |   | 2     | 4  | 4     | 4     | 4     |   |
|     |  |   | 147  |       |   | 157   |    |       |       | 216   |   |
|     |  |   | 0,68 |       |   | 0,73  |    |       |       | 1,00  |   |

Spannhöhe

Spannbreite

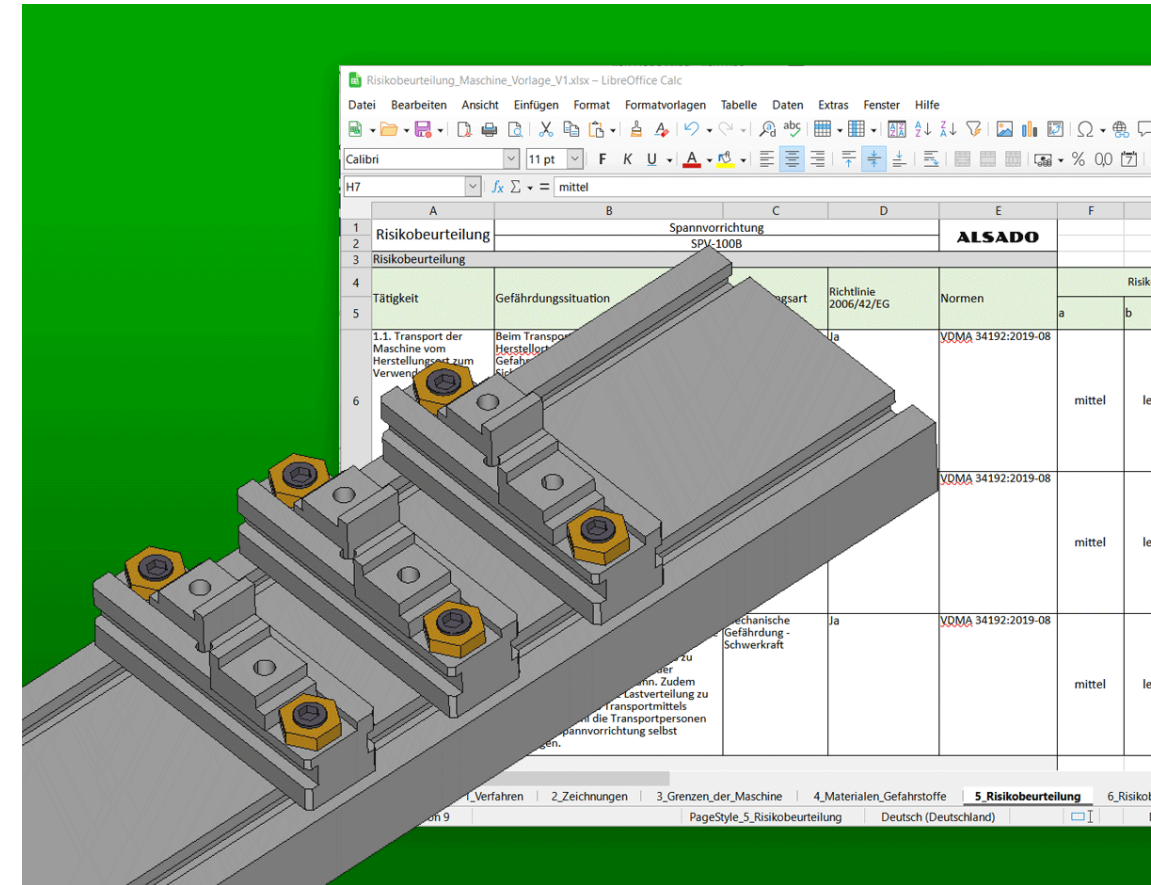
Mittelwert: Summe: 0



# Product safety (CE) in LibreOffice Calc

- Create an overview of all possible product safety directives from the european union for your selected product concept
- Evaluate each one of them and decide if it is applicable. Each directive has a defined scope, written at the beginning of the directive document.
- Get an overview of (harmonized) standards and decide for each one if it is applicable for your product concept
- Create a risk assessment based on ISO 12100

**Software used:** LibreOffice Calc



# Preliminary design in LibreOffice Calc

- Determining as many details of the product based on functional (product concept) and product safety (risk assessment) requirements
- Determine properties of product by calculations or decision trees:
  - Factor of safety
  - Forces
  - Dimensions
  - Tolerances
  - Surface roughness
  - Temperature
  - Time
  - ...

**Software used:** LibreOffice Calc

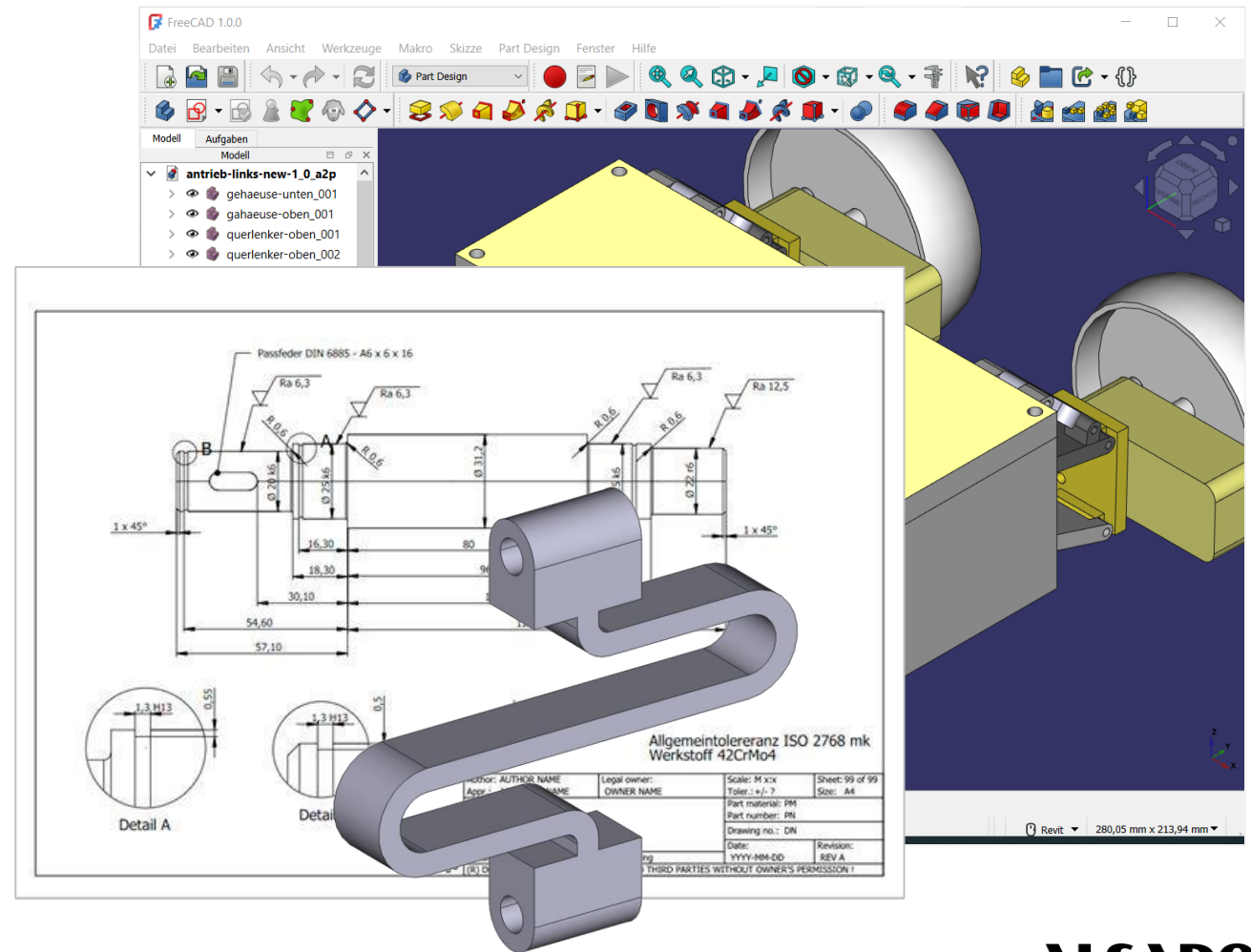
The screenshot displays the LibreOffice Calc interface with a spreadsheet titled 'Zerspankraftrechner\_Drehen.xlsx'. The spreadsheet contains a table with 28 rows and 4 columns (A, B, C, D). The table lists various parameters and their values for a turning process. A hand-drawn diagram of a turning process is overlaid on the spreadsheet, showing a workpiece being turned on a lathe. The diagram includes labels for forces (F<sub>t</sub>, F<sub>c</sub>, F<sub>d</sub>), dimensions (D, d, L, l, s, a<sub>p</sub>), and angles (K, α). The diagram is divided into several sections, each labeled with a number (1-12) and a description of the forces or dimensions involved.

|    | A                                       | B                  | C               | D   |
|----|---|--------------------|-----------------|---|
| 1  | Zerspankraft - Drehen                   | Berechnungsvorlage |                 |   |
| 2  |   |                    |                 |   |
| 3  |   |                    |                 |   |
| 4  |   |                    |                 |   |
| 5  |   |                    |                 |   |
| 6  |   |                    |                 |   |
| 7  |   |                    |                 |   |
| 8  |   |                    |                 |   |
| 9  |   |                    |                 |   |
| 10 |   |                    |                 |   |
| 11 | Schnitttiefe                            | a <sub>p</sub>     |                 | 3mm                                       |
| 12 | Vorschub pro Umdrehung                  | f <sub>z</sub>     |                 | 0,63mm                                    |
| 13 | Einstellwinkel                          | K                  |                 | 45°                                       |
| 14 | Zerspankraftwert                        | 1-z                |                 | 0,7                                       |
| 15 | Zerspankraftwert                        | 1-x                |                 | 0,3835                                    |
| 16 | Zerspankraftwert                        | 1-y                |                 | 0,5067                                    |
| 17 | Zerspankraftwert                        | kc1.1              |                 | 2260 N/m                                  |
| 18 | Zerspankraftwert                        | kf1.1              |                 | 364 N/m                                   |
| 19 | Zerspankraftwert                        | kp1.1              |                 | 311 N/m                                   |
| 20 | Verschleißmarkenbreite                  | VB                 |                 | 0,7mm                                     |
| 21 | Schnittgeschwindigkeit                  | v <sub>c</sub>     |                 | 95 m/min                                  |
| 22 | Vorschubgeschwindigkeit                 | v <sub>f</sub>     |                 | 0,0967 m/min                              |
| 23 | Passivgeschwindigkeit                   | v <sub>p</sub>     |                 | 0 m/min                                   |
| 24 |   |                    |                 |   |
| 25 | Spanungsbreite                          | b                  | 4,2426406871 mm | $b = a_p / \sin(K)$                       |
| 26 | Spanungsdicke                           | h                  | 0,4454772721 mm | $h = f_z * \sin(K)$                       |
| 27 | Verschleißkorrekturfaktor Schnittkraft  | K <sub>vc</sub>    | 1,35            | $K_{vc} = 1 + 0,05 * (VB/0,1 \text{ mm})$ |
| 28 | Verschleißkorrekturfaktor Vorschubkraft | K <sub>vf</sub>    | 1,7             | $K_{vf} = 1 + 0,1 * (VB/0,1 \text{ mm})$  |

# Detailed design in FreeCAD

- Based on preliminary design, create a virtual representation of the final product.
- 3D CAD
- Technical drawings
  - Single part manufacturing drawing
  - Assembly drawings
- Export STEP, DXF, PDF

**Software used:** FreeCAD

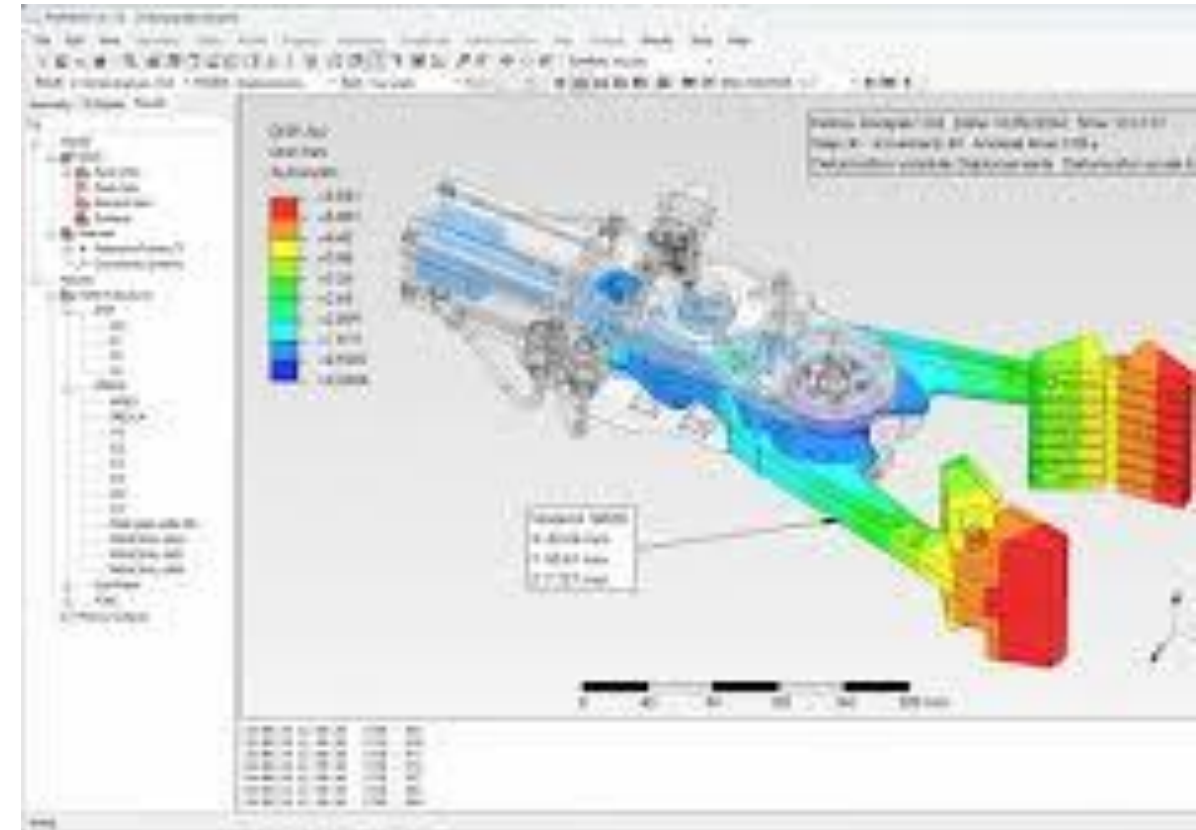




# FEM simulation in PrePoMax

- For all parts that cannot be calculated analytically in the preliminary design step a FEM simulation needs to be performed:
  - Boundary conditions
  - Mesh
  - Solver

**Software used:** PrePoMax



# On-premise product-lifecycle-management using Subversion

- Folder structure Versioning and user management with SVN (SVN Server, SVN client, Lock)
- Centralized server with server hardware and clients on same local network
- Redundant raid storage
- Redundant power supply:  
Uninterruptable power supply (UPS)
- Store data externally in regular time intervalls

**Software used:** VisualSVN, TortoiseSVN



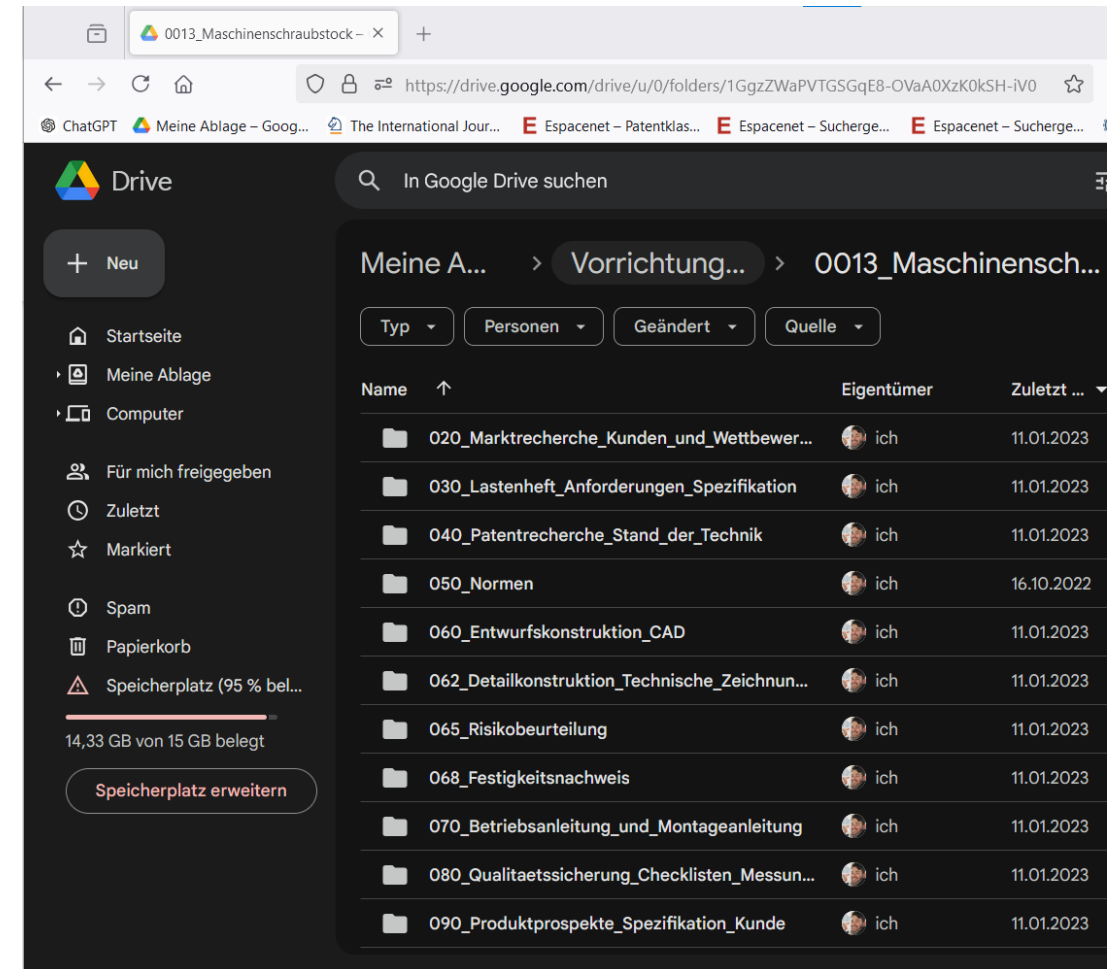
A screenshot of a file explorer window showing a directory structure. The directory names are listed on the right side of the window, each preceded by a small yellow folder icon. The names are: 020\_Marktrecherche\_Kunden\_und\_Wettbewerber, 030\_Lastenheft\_Anforderungen\_Spezifikation, 040\_Patentrecherche\_Stand\_der\_Technik, 050\_Normen, 060\_Entwurfskonstruktion\_CAD, 062\_Detailkonstruktion\_Technische\_Zeichnungen, 065\_Risikobeurteilung, 068\_Festigkeitsnachweis, 070\_Betriebsanleitung\_und\_Montageanleitung, 080\_Qualitaetssicherung\_Checklisten\_Messungen, and 090\_Produktprospekte\_Spezifikation\_Kunde.

- 020\_Marktrecherche\_Kunden\_und\_Wettbewerber
- 030\_Lastenheft\_Anforderungen\_Spezifikation
- 040\_Patentrecherche\_Stand\_der\_Technik
- 050\_Normen
- 060\_Entwurfskonstruktion\_CAD
- 062\_Detailkonstruktion\_Technische\_Zeichnungen
- 065\_Risikobeurteilung
- 068\_Festigkeitsnachweis
- 070\_Betriebsanleitung\_und\_Montageanleitung
- 080\_Qualitaetssicherung\_Checklisten\_Messungen
- 090\_Produktprospekte\_Spezifikation\_Kunde

# Alternative: Google Drive

- Same folder structure
- Integrated versioning
- User management with access rights
- Locking and unlocking files
- Centralised Cloud storage – free plan is good enough for most projects
- Might not be suitable for everyone because of potential data breaches

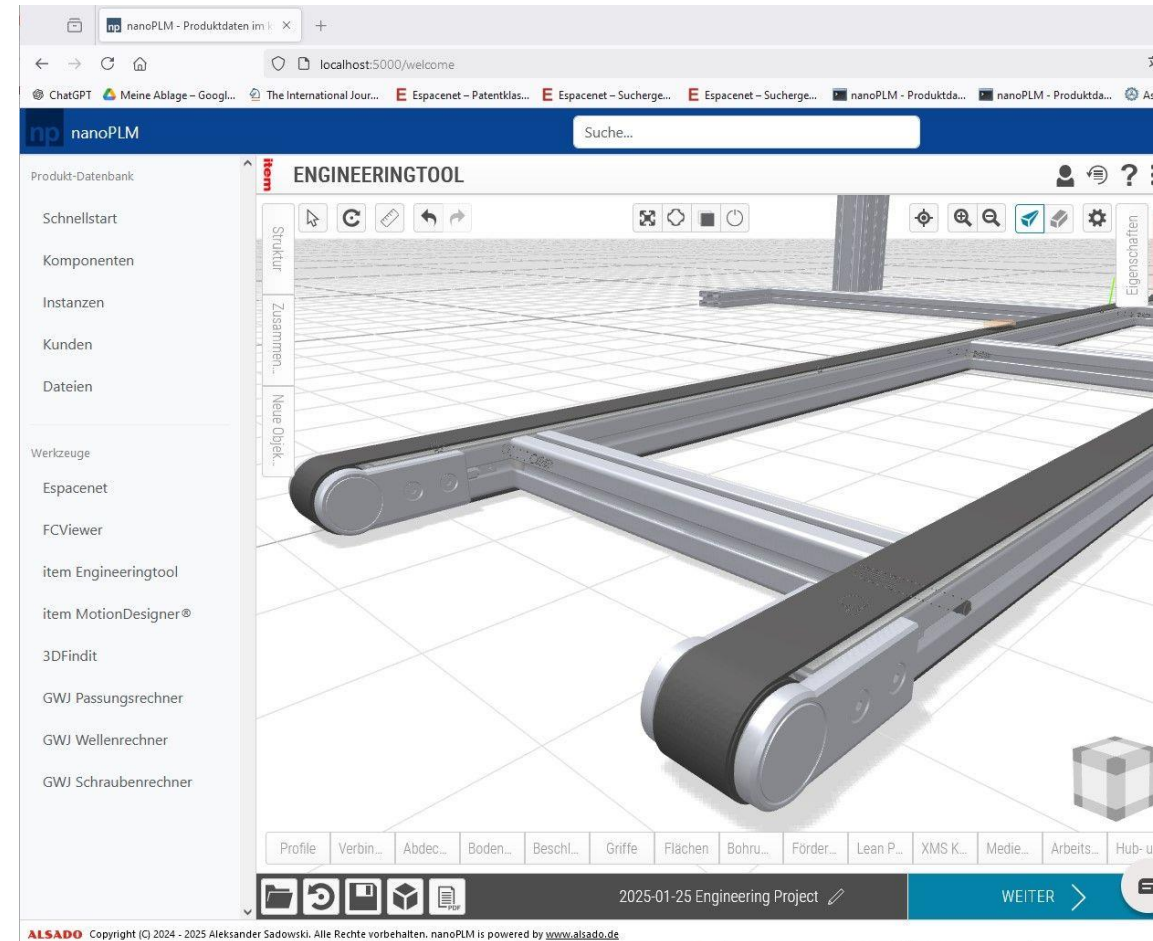
**Software used:** Google Drive



# Benefits of a PLM solution

- File structure and consistency
- Versioning
- User management
- Fast search
- Workflow templates
- Integration tools for automating tasks throughout the product lifecycle, including the product development process

=> Development of the open-source PLM „nanoPLM“





# Contact

Product development in mechanical engineering using open-source software – A guide for small machine manufacturers in the European Union

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