Sustainable Software Product Lines via Generation

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Huawei 2023 Visit: Feb?, 2023

Generate All Things with Drasil

- **Goal** — Improve software sustainability and productivity
- **Ideas**
  - Adapt a software product line approach
  - Build on success of MDSE
  - Value all documents, not just code
  - Start with well-understood domains
- **Solution**
  - Capture (codify) knowledge once
  - Generate all documentation and code
  - Idealized dev process for well-understood software
- **Implement Partial Solution — Drasil**

Product Lines

Product Lines in User Manual

PRODUCT SPECIFICATIONS

The appearance and specifications listed in this manual may vary due to constant product improvements.

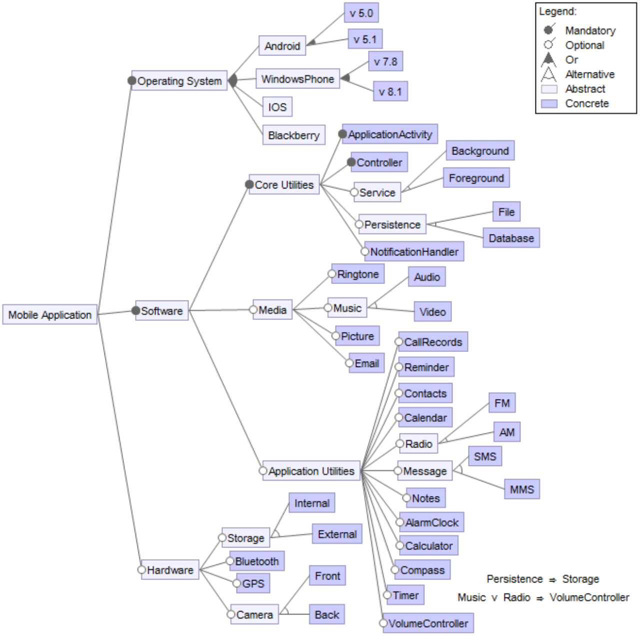
Electrical requirements: 115 V, 60 Hz

Min. / Max. water pressure: 20 - 120 psi (138 - 827 kPa)

Model	LFCC22426*
Description	Counter-depth, French door refrigerator, bottom freezer
Net weight	243 lb (110 kg)

Model	LFCS27596*
Description	Standard-depth, Door-in-Door French door refrigerator, bottom freezer
Net weight	284 lb (129 kg)

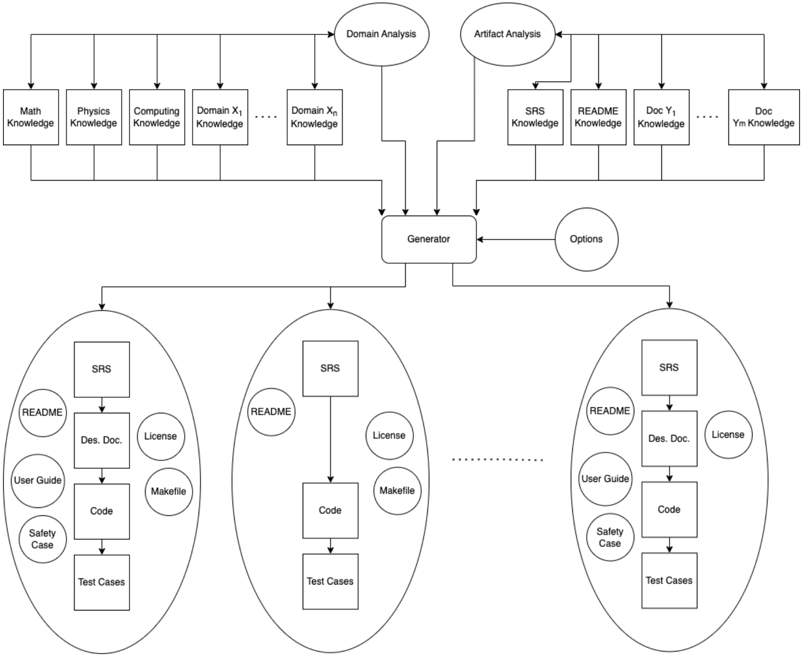
Model	LFCC23596*
Description	Counter-depth, Door-in-Door French door refrigerator, bottom freezer
Net weight	269 lb (122 kg)



Usman et al. (2017)

Build on Success of MDSE

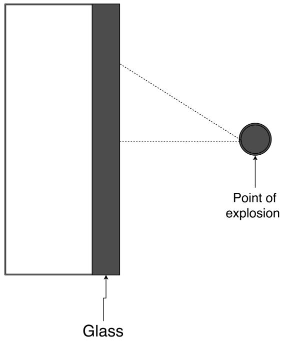
- Codify (capture) code and non-code info together
  - Natural language (text)
  - Definitions
  - Assumptions
  - Derivations
  - Rationale
  - Abstract theory
  - User characteristics
  - Nonfunctional Requirements
  - Etc.
- Generate all artifacts from one framework
  - Requirements
  - User manuals
  - README
  - Build scripts, dev environment (CI etc)
  - Assurance case
  - Code (in different languages)
  - Test cases
  - etc.


Domain Analysis
Artifact Analysis
Math Knowledge
Physics Knowledge
Computing Knowledge
Domain X1 Knowledge
....
Domain Xn Knowledge
SRS Knowledge
README Knowledge
Doc Y1 Knowledge
....
Doc Ym Knowledge
Generator
Options
SRS
README
Des. Doc.
License
User Guide
Makefile
Code
Safety Case
Test Cases
SRS
README
License
Makefile
Code
Test Cases
....
SRS
README
Des. Doc.
License
User Guide
Code
Safety Case
Test Cases

Why Generate All Things?

- Different views of the same knowledge
- Generate the view needed by the audience
- Change to different natural languages
- Stay abstract longer
- Certification
- Documentation improve productivity, sustainability
- Reusability
- Modifiability
- One source helps synchronization

GlassBR



Given

- dimensions of glass plane
- glass type
- explosion characteristics
- tolerable breakage probability

Predict whether the glass will withstand the explosion

Drasil Inputs:

- Program Name: GlassBR
- Authors: Nikitha K and Spencer S
- Symbols: tolerable load ($\hat{q}_{\text{tol}}$), Risk of failure (B), ...
- Assumptions: Load duration factor constant,
- Data definitions: relation for B, ...
- Design decisions:

  Modularity (input module),
  Implementation Type (Program),
  Logging (Yes),
  Input Structure (Bundled),
  Constant Structure (Inlined),
  Constant Rep (Constants),
  Real Number Rep (Double),
  ...

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    ...

```
/glassbr
  /Website/GlassBR_SRS.html
  /Website/GlassBR_SRS.css
  /SRS/bibfile.bib
  /SRS/Makefile
  /SRS/GlassBR_SRS.tex
  /SRS/GlassBR_SRS.pdf
  /src/python
  /src/python/README.md
  /src/python/InputParameters.py
  /src/python/Calculations.py
  /src/python/Makefile
  /src/python/doxConfig
  ...
```

```
...
 /src/java/GlassBR/Calculations.java
 /src/java/Makefile
 /src/java/README.md
 ...
 /src/cpp/GlassBR
 /src/cpp/ReadTable.cpp
 /src/cpp/InputFormat.hpp
 /src/cpp/Calculations.cpp
 ...
 /src/swift/Calculations.swift
 ...
 /src/csharp/Control.cs
 ...
```

```
/glassbr
  /Website/GlassBR_SRS.html
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  /src/python/doxConfig
  ...
```

```
...
 /src/java/GlassBR/Calculations.java
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 ...
 /src/cpp/GlassBR
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 /src/cpp/InputFormat.hpp
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 ...
 /src/swift/Calculations.swift
 ...
 /src/csharp/Control.cs
 ...
```
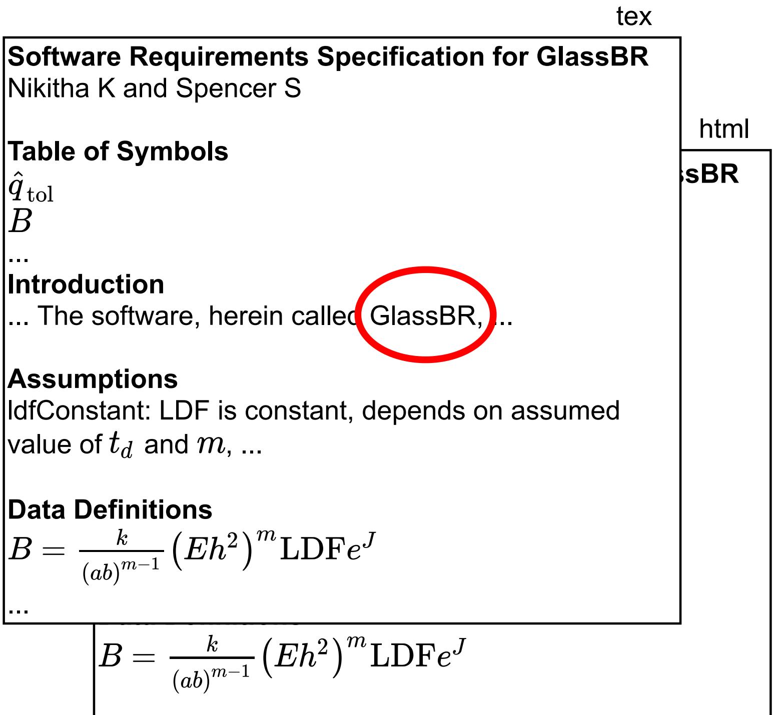



Software Requirements Specification for GlassBR
Nikitha K and Spencer S

Table of Symbols
$\hat{q}_{\text{tol}}$
B
...
Introduction
... The software, herein called GlassBR, ...

Assumptions
ldfConstant: LDF is constant, depends on assumed value of t_d and m, ...

Data Definitions
$$B = \frac{k}{(ab)^{m-1}}\left(Eh^2\right)^m \mathrm{LDF} e^J$$
...

ssBR

$$B = \frac{k}{(ab)^{m-1}}\left(Eh^2\right)^m \mathrm{LDF} e^J$$

README.md

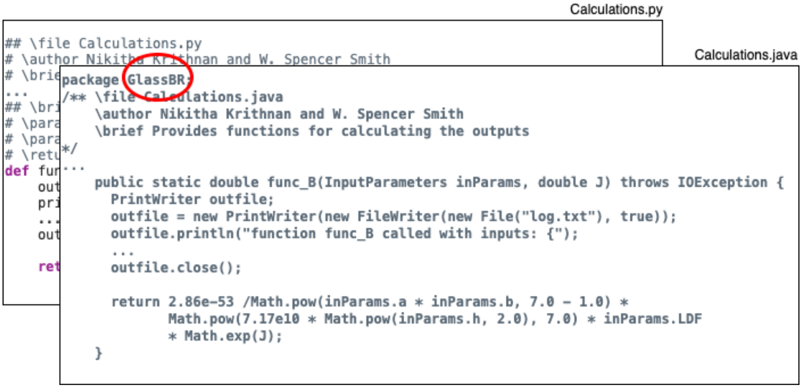
GlassBR
Authors Nikitha K and Spencer S
How to Run the Program: In your terminal command line, enter the same directory as this README file. Then enter the following line

```
make run RUNARGS=input.txt
```

Configuration Files: SDF.txt, TSD.txt must be in the same directory as the executable to run successfully
Versioning: Python Version 3.5.1

```
...

build:

run: build
python Control.py
...
```

```
build: GlassBR/Control.class
...
GlassBR/Control.class:
GlassBR/Control.java ...
    javac GlassBR/Control.java

run: build
    java GlassBR.Control $(RUNARGS)
...
```



```
## \file Calculations.py
# \author Nikitha Krithnan and W. Spencer Smith
# \brie
...
## \bri
# \para
# \para
# \retu
def fur
    out
    pri
    ...
    out

    ret
```

```
package GlassBR;
/** \file Calculations.java
    \author Nikitha Krithnan and W. Spencer Smith
    \brief Provides functions for calculating the outputs
*/
...
    public static double func_B(InputParameters inParams, double J) throws IOException {
      PrintWriter outfile;
      outfile = new PrintWriter(new FileWriter(new File("log.txt"), true));
      outfile.println("function func_B called with inputs: {");
      ...
      outfile.close();

      return 2.86e-53 /Math.pow(inParams.a * inParams.b, 7.0 - 1.0) *
             Math.pow(7.17e10 * Math.pow(inParams.h, 2.0), 7.0) * inParams.LDF
             * Math.exp(J);
    }
```

J_{tol} in SRS.pdf

Refname	**DD:sdfTol**
Label	Stress distribution factor (Function) based on Pbtol
Symbol	J_{tol}
Units	Unitless
Equation	$J_{\text{tol}} = \ln\left(\ln\left(\frac{1}{1-P_{\text{btol}}}\right)\frac{\left(\frac{a}{1000}\frac{b}{1000}\right)^{m-1}}{k\left(E\cdot 1000\left(\frac{h}{1000}\right)^{2}\right)^{m}LDF}\right)$
Description	J_{tol} is the stress distribution factor (Function) based on Pbtol (Unitless) P_{btol} is the tolerable probability of breakage (Unitless) a is the plate length (long dimension) (m) b is the plate width (short dimension) (m) m is the surface flaw parameter $\left(\frac{\text{m}^{12}}{\text{N}^{7}}\right)$ k is the surface flaw parameter $\left(\frac{\text{m}^{12}}{\text{N}^{7}}\right)$ E is the modulus of elasticity of glass (Pa) h is the minimum thickness (m) LDF is the load duration factor (Unitless)

J_{tol} in SRS.tex

```
...
Label & Stress distribution factor (Function) based on
    Pbtol

\\ \midrule \\
Symbol & ${J_{\text{tol}}}$

\\ \midrule \\
Units & Unitless

\\ \midrule \\
Equation & \begin{displaymath}
            {J_{\text{tol}}}=\ln\left(\ln\left(\frac
                {1}{1-{P_{\text{b}\text{tol}}}}\right) \
                frac{\left(\frac{a}{1000} \frac{b}{1000}\
                right)^{m-1}}{k \left(E\cdot{}1000 \left(\
                frac{h}{1000}\right)^{2}\right)^{m} LDF}\
                right)
            \end{displaymath}
\\ \midrule \\
Description & ...
```

J_{tol} in SRS.html

```
...
<th>Equation</th>
<td>
\[{J_{\text{tol}}}=\ln\left(\ln\left(\frac{1}{1-{P_{\text
    {b}\text{tol}}}}\right) \frac{\left(\frac{a}{1000} \
    frac{b}{1000}\right)^{m-1}}{k \left(E\cdot{}1000 \
    left(\frac{h}{1000}\right)^{2}\right)^{m} LDF}\right)
    \]
</td>
...
```

J_{tol} in Python

```
## \brief Calculates stress distribution factor (Function
    ) based on Pbtol
# \param inParams structure holding the input values
# \return stress distribution factor (Function) based on
    Pbtol
def func_J_tol(inParams):
    outfile = open("log.txt", "a")
    print("function func_J_tol called with inputs: {",
        file=outfile)
    print("  inParams = ", end="", file=outfile)
    print("Instance of InputParameters object", file=
        outfile)
    print("  }", file=outfile)
    outfile.close()

    return math.log(math.log(1.0 / (1.0 - inParams.P_btol
        )) * ((inParams.a / 1000.0 * (inParams.b /
        1000.0)) ** (7.0 - 1.0) / (2.86e-53 * (7.17e10 *
        1000.0 * (inParams.h / 1000.0) ** 2.0) ** 7.0 *
        inParams.LDF)))
```

J_{tol} in Java

```
/** \brief Calculates stress distribution factor (
    Function) based on Pbtol
    \param inParams structure holding the input
        values
    \return stress distribution factor (Function)
        based on Pbtol
*/
public static double func_J_tol(InputParameters
    inParams) throws IOException {
    PrintWriter outfile;
    outfile = new PrintWriter(new FileWriter(new File
        ("log.txt"), true));
    ...
    return Math.log(Math.log(1.0 / (1.0 - inParams.
        P_btol)) * (Math.pow(inParams.a / 1000.0 * (
        inParams.b / 1000.0), 7.0 - 1.0) / (2.86e-53
        * Math.pow(7.17e10 * 1000.0 * Math.pow(
        inParams.h / 1000.0, 2.0), 7.0) * inParams.
        LDF)));
}
```

J_{tol} in Drasil (Haskell)

```
tolStrDisFacEq :: Expr
tolStrDisFacEq = ln (ln (recip_ (exactDbl 1 $- sy pbTol))
  `mulRe` (((sy plateLen $/ exactDbl 1000) `mulRe` (sy
     plateWidth $/ exactDbl 1000)) $^ (sy sflawParamM $-
      exactDbl 1) $/
    (sy sflawParamK `mulRe` ((sy modElas `mulRe` exactDbl
        1000 `mulRe`
    square (sy minThick $/ exactDbl 1000)) $^ sy
       sflawParamM) `mulRe` sy lDurFac)))
```

J_{tol} without Unit Conversion

```
tolStrDisFacEq :: Expr
tolStrDisFacEq = ln (ln (recip_ (exactDbl 1 $- sy pbTol))
  `mulRe` ((sy plateLen `mulRe` sy plateWidth) $^ (sy
      sflawParamM $- exactDbl 1) $/
    (sy sflawParamK `mulRe` ((sy modElas `mulRe`
    square (sy minThick)) $^ sy sflawParamM) `mulRe` sy
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```

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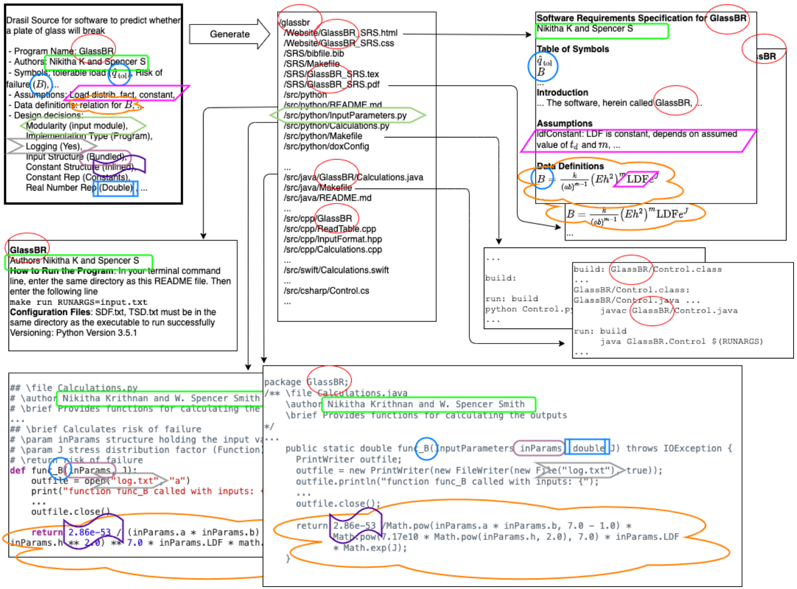

Drasil Source for software to predict whether a plate of glass will break

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sBR

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```
build: GlassBR/Control.class
...
GlassBR/Control.class:
GlassBR/Control.java ...
     javac GlassBR/Control.java

run: build
     java GlassBR.Control $(RUNARGS)
...
```

```
## \file Calculations.py
# \author Nikitha Krithnan and W. Spencer Smith
# \brief Provides functions for calculating the
...
## \brief Calculates risk of failure
# \param inParams structure holding the input va
# \param J stress distribution factor (Function)
# \return risk of failure
def func_B(inParams, J):
    outfile = open("log.txt", "a")
    print("function func_B called with inputs: {
    ...
    outfile.close()

    return 2.86e-53 / (inParams.a * inParams.b)
inParams.h ** 2.0) ** 7.0 * inParams.LDF * math.
```

```
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    \brief Provides functions for calculating the outputs
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        * Math.exp(J);
    }
```

Idealized Process

- From wu paper

Capturing Knowledge: Inputs

- Probably won’t have time to discuss

Concluding Remarks

- **Take Home Message** — Goal of Improving Sustainability and Productivity via a Generate All Things Approach

References I

Muhammad Usman, Muhammad Zohaib Iqbal, and Muhammad Uzair Khan. A product-line model-driven engineering approach for generating feature-based mobile applications. *Journal of Systems and Software*, 123:1–32, 01 2017. doi: 10.1016/j.jss.2016.09.049.

Image Credits

- Apple Product Line Image
- Dodge Lineup