# Major Aspects

* Parallel (multithreaded) optimization routine to be developed
  + Parallel execution and wrapping of BS-Engine is largely done in proof of concept.
  + Development of optimization routine/solver
    - **50 hours**
* Plotting ability in 2-D
  + Through Telerik ($899 per developer)
    - Also provides user interface improvements to win forms
  + <http://www.telerik.com/products/winforms/chartview.aspx>
    - **20 hours**
* Model display in 3-D/like 3-D to scale
  + <https://www.devdept.com/Products/Eyeshot> (€690 per developer)
    - Might be too powerful, allowing full CAD features, but export and display viewport looks worthwhile and is royalty free.
    - **30 hours**
* Database/file support (SQLite, <https://sqlite.org/appfileformat.html>, free software)
  + Existing BS solutions
  + BS existing models
  + Linear and non-linear materials
  + Projects
  + **40 hours**
* Licensing solution (Flexara/other, flexera pricing unknown)
  + Depends on solution, guestimate 30 hours, but I would recommend saving to the end
* Protecting BSEngine license
  + **20 hours**
* Out of band BSEngine updates (note, will need a server to distribute from, which is not estimated)
  + **20 hours**
* Export (to what format?)
  + Depends on export options and formats
* Installer – Wix toolset (<http://wixtoolset.org>)
  + **20 hours**
* BS Engine error detection
  + **30 hours**
* Self-update support? (note, will need a server to distribute from, which is not estimated)
  + **10 hours**
* Results presentation tabs (approximately ten results tabs)
  + **60 hours**
* Find optimal workflow
  + **40 hours**
* Find existing workflow
  + **20 hours**
* Run particular design workflow
  + **20 hours**
* Suggestion ability on how to meet requirements (need to know how to provide)
  + **20 hours**
* Detecting kinks on riser (need to know how)
  + **10 hours**

Overall **440 hours** “guestimate” and **$1,730** in licensing

# Phases

1. “Scaffolding” application
   1. Installer setup (Wix)
   2. Setup continuous integration (perhaps teamcity or dropbox share)
   3. Initial databases and user interface for them
   4. Bundling of BS Engine
   5. Demonstrate 2D plotting, and 3D model
   6. Support providing data for materials and models
2. Run particular design workflow
   1. User interface for a particular design case
   2. File databases supporting a single design case
   3. Reports for results of single design case
   4. Saving to existing results
3. Find optimal workflow
   1. User interface for optimization workflow, borrowing from single design
   2. Development of optimization routine
   3. User interface around running the FEM solver
   4. Reports for results of optimization
4. Find existing workflow and polishing
   1. User interface for finding an existing workflow
   2. Testing and fixes for optimization routine as needed (Client testing/feedback)
   3. Error detection and added robustness to BS engine wrapping
   4. Add suggestions for satisfying requirements
5. Quality assurance and testing
   1. Testing of the application, trying to break it
   2. Incorporate client feedback
6. Licensing and protection
   1. Add selected licensing model
   2. Protect code

# Development Notes

* Visual Studio 2017 Enterprise
* Bitbucket to host GIT repository for version control
* Trello boards for tracking task statuses (to do / currently working on / completed)
* Team city build server if interested in “continuous integration”
* Obfuscate code on release and protect licensing with commercial solution (Flexera?)

# MindMap requirements and notes

* Technology Stack
  + Visual Studio 2017
  + Microsoft .NET Framework 4.5
  + Windows Forms
    - For user interface
  + SQL Lite
    - Database files as application file format: <https://sqlite.org/appfileformat.html>
    - Material Database
      * Linear Materials
        + Material ID
        + Elastic Modulus [MPa]
        + Temperature [C] or [F]
        + Density [kg/m3]
      * Non-linear materials
        + Material ID
        + Data points

x: Strain [-] or [%]

y: Stress [MPa]

* + - * + Temperature [C] or [F]
        + Density [kg/m3]
      * Display the data and graph (if non-linear) when selected
    - FE Model Database – Contains standard BS model geometries, or segment combinations
      * Minimal
        + Cone
      * Classic
        + Cylinder, root segment
        + Cone, main BS body
        + Cylinder, BS tip
      * 2-segment BS
        + Cylinder, root segment
        + Cone, 1st main body segment
        + Cylinder, metal flange
        + Cone, 2nd main body segment
        + Cylinder, BS tip
      * 3-segment BS
        + Cylinder, root segment
        + Cone, 1st main body segment
        + Cylinder, metal flange
        + Cone, 2nd main body segment
        + Cylinder, metal flange
        + Cone, 3rd main body segment
        + Cylinder, BS tip
    - Historical BS Database – Contains BS geometries made before
      * FE model type used
      * BS external dimensions and ID
      * Project name(s)
      * Date
    - Project Database – Contains all previous projects actively saved into the database, complete data
  + BSEngine
* Export
  + Format(s)? Exporting through SQLite is straightforward, but there will need to be a translation for each format.
* Report
  + PDF Report generation
    - Likely requires a commercial library to build the PDF report.
* Project Information
  + Input of Project Name, Riser ID, Client, and Designer
  + Tracks Software name, software version, time and date
* FE Analysis Settings
  + Settings for BS Engine: Iteration Tolerance, Maximum iterations, etc.
  + Riser parameters: Riser length outside of BS tip, number of elements per meter. Option to reset to default.
  + Thread count (execution in parallel already demonstrated)
* Data
  + Riser
    - Data, input to bsengine:
      * Riser ID
      * Max OD, etc.
      * Capacity Curve normal operation
        + N data points (x: curvature, y: tension)
      * Capacity Curve abnormal operation
        + N data points (x: curvature, y:tension)
  + Load Cases
    - Enable user input
      * Normal operation
        + N data points (x: deflection angle, y: tension)
      * Abnormal operation
        + N data points (x: deflection angle, y: tension)
      * Display both cases as graphs
  + Type of analysis
    - Find optimal BS
      * Select Desired FE model from database
        + Allow editing database
        + Figure of model should be displayed
        + Allow locking the material
        + Indicate fixed length segments
      * Input BS geometry constraints
        + Min root OD, max root OD, min length, max length, etc.
      * Select desired materials from material database
        + Allow analysis at up to two temperature levels
      * “Run Analysis”
        + Generate BS-engine inputs and run
        + Find optimal solution using minimum length and or minimum volume
        + Normally two cases, normal and abnormal operation, and two temperature levels, one BS that fulfils all requirements
        + Each case max curvature must be less than the capacity curve allows
      * Display result under results presentation
    - Find best existing BS
      * Select BS to analyze
        + Note, show alert during solve if existing database contains better solution?
        + Display scale model of BS, 3d like
      * Select materials, again up to two temperatures
      * “Run Analysis” – search existing database
    - Run load cases on Given BS
      * Run a specific case and allow adding to the BS database
      * Same selections for running the case as above
  + Results Presentation
    - Find optimal BS
      * Clearly indicate whether optimal solution was found
      * Allow user to adjust parameter that was on a constraint
      * If no solution, give indication on what should change
        + Shorter/longer/wider/different material/etc
      * Tabs
        + Scope tab

Summary of all the inputs associated with the optimal analysis

* + - * + Summary results tab

Tables

Normal Operation

Columns: Category, Load Case numbers

Rows: Deflection angle, tension, etc.

Abnormal Operation

Same as normal

Graphics (Plot)

Plot normal operation capacity curve

Plot abnormal operation capacity curve

Plot normal operation BS performance curve

Plot Abnormal operation BS performance curve

* + - * + Load case results tab
        + BS performance tab
    - Find Best existing BS
      * Clearly indicate if none, one or how many selected BS designs fulfill all requirements
      * Smallest/shortest BS design should be recommended
      * If none, indicate what should be changed, shorter/longer/wider/material/etc
      * Same presentation tabs as above
    - Run BS Load Cases
      * Same client area as above
* Challenges
  + Detecting errors from BS-Engine
    - Handling of failed convergence/other issues. This is a bit of a hand tuning operation with guiding FEM parameters
  + Licensing
    - BS-Engine
      * Unpacking licensing when using BS-Engine and remove when done
      * Allow updates out of band from UltraBend
      * Two licenses, one for UltraBend and one for BS-Engine
      * Open to suggestions
    - UltraBend
      * Needs to be license protected
      * FlexLM?
        + SafeNet, KeyLok, Flexera, Pace, Marx, and many others.
        + CodeMeter?
      * Use an obfuscator
      * Provide license agreement for users
    - Multithreading
      * Optimization routine
      * Automatically choose thread count
    - Optimization
      * Develop rational and efficient optimization routine
      * Primary optimization around BS length
      * Secondary optimization around volume
* Compare linear vs. non-linear material results
  + Table showing linear/non-linear results side by side
  + Figure comparing linear and non-linear bent geometry
  + Plot comparison of curvature, tension, shear force, bending moment
* Detect “kink” in riser just outside the BS (How?)
* On exit offer save project, and to add to historical BS database