RT-139: Software Reliability Modeling

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Research Task / Overview

Department of Defense (DoD) increasingly depends on software intensive systems

- Mission and life critical
- Must preserve high reliability and availability

Urgency to deploy new technologies and military capabilities may result in

- Inadequate reliability testing
- Severe economic damage and loss of life

- Recent National Academies report on Enhancing Defense System Reliability recommends
  - Use of reliability growth models to direct contractor design and test activities

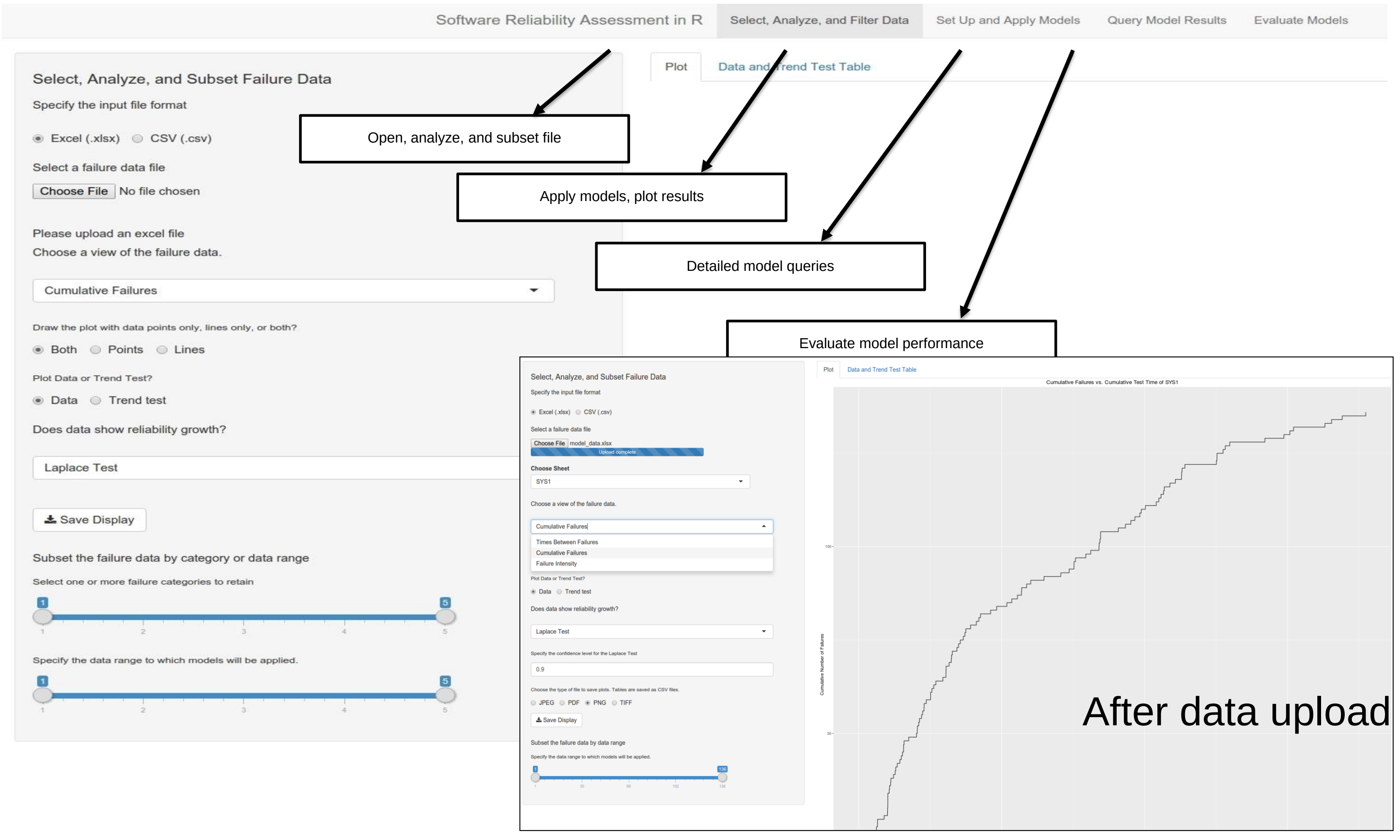
Tools such as CASRE (Computer-Aided Software Reliability Estimation Tool)

- Caution: Users strongly advised to study underlying mathematics

Contribution: Development of open source tool to address these issues

Data & Analysis

SFRAT - Tab view



Software Reliability Assessment in R
Select, Analyze, and Filter Data
Set Up and Apply Models
Query Model Results
Evaluate Models
Plot
Data and Trend Test Table
Open, analyze, and subset file
Apply models, plot results
Detailed model queries
Evaluate model performance
Cumulative Failures vs. Cumulative Test Time of SYS1
Cumulative Number of Failures

Select, Analyze, and Subset Failure Data

Specify the input file format

● Excel (.xlsx) ○ CSV (.csv)

Select a failure data file

Choose File No file chosen

Please upload an excel file

Choose a view of the failure data.

Cumulative Failures

Draw the plot with data points only, lines only, or both?

● Both ○ Points ○ Lines

Plot Data or Trend Test?

● Data ○ Trend test

Does data show reliability growth?

Laplace Test

Save Display

Subset the failure data by category or data range

Select one or more failure categories to retain

Specify the data range to which models will be applied.

After data upload

Select, Analyze, and Subset Failure Data

Specify the input file format

● Excel (.xlsx) ○ CSV (.csv)

Select a failure data file

Choose File model_data.xlsx

Upload complete

Choose Sheet

SYS1

Choose a view of the failure data.

Cumulative Failures

Times Between Failures
Cumulative Failures
Failure Intensity

Plot Data or Trend Test?

● Data ○ Trend test

Does data show reliability growth?

Laplace Test

Specify the confidence level for the Laplace Test

0.9

Choose the type of file to save plots. Tables are saved as CSV files.

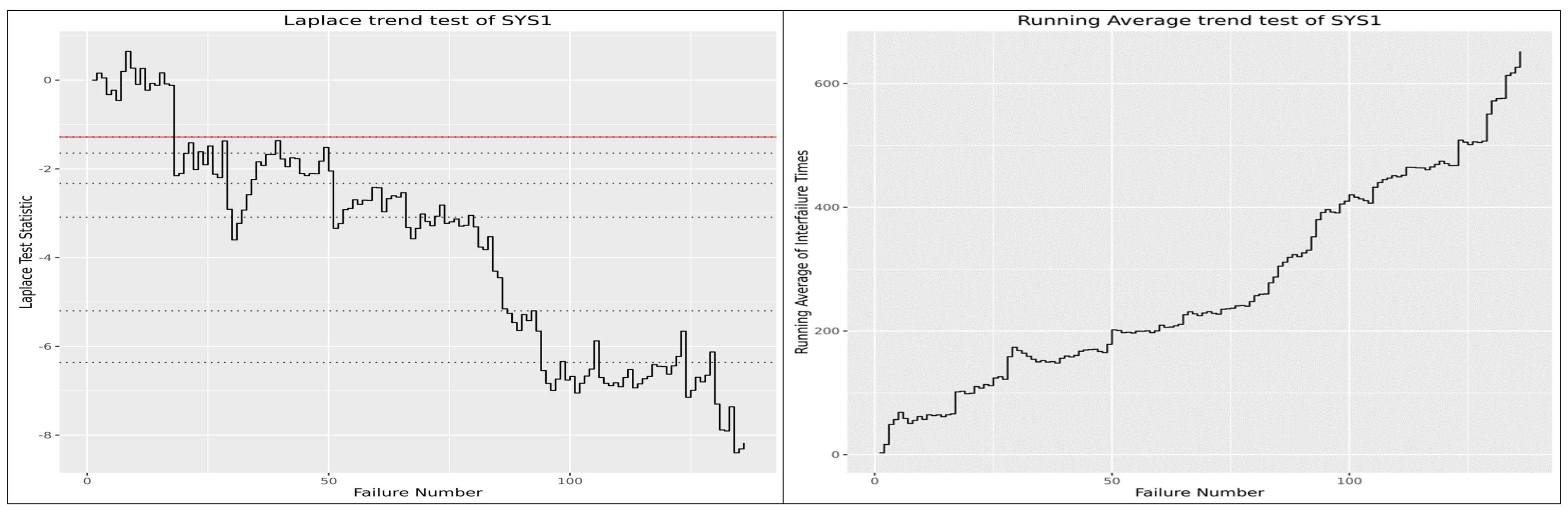
○ JPEG ○ PDF ● PNG ○ TIFF

Save Display

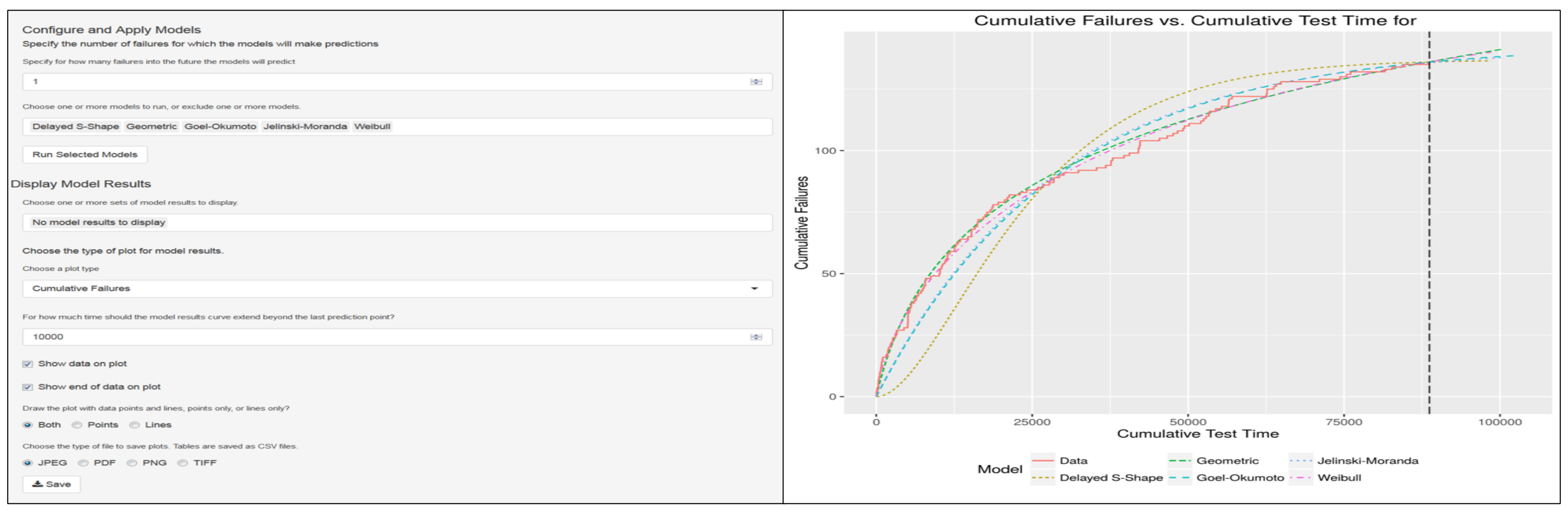
Subset the failure data by data range

Specify the data range to which models will be applied.

Tab1: Laplace Trend Test and Running arithmetic average



Tab 2: options and Cumulative failure data view



Configure and Apply Models

Specify the number of failures for which the models will make predictions

Specify for how many failures into the future the models will predict

1

Choose one or more models to run, or exclude one or more models.

Delayed S-Shape Geometric Goel-Okumoto Jelinski-Moranda Weibull

Run Selected Models

Display Model Results

Choose one or more sets of model results to display.

No model results to display

Choose the type of plot for model results.

Choose a plot type

Cumulative Failures

For how much time should the model results curve extend beyond the last prediction point?

10000

☑ Show data on plot

☑ Show end of data on plot

Draw the plot with data points and lines, points only, or lines only?

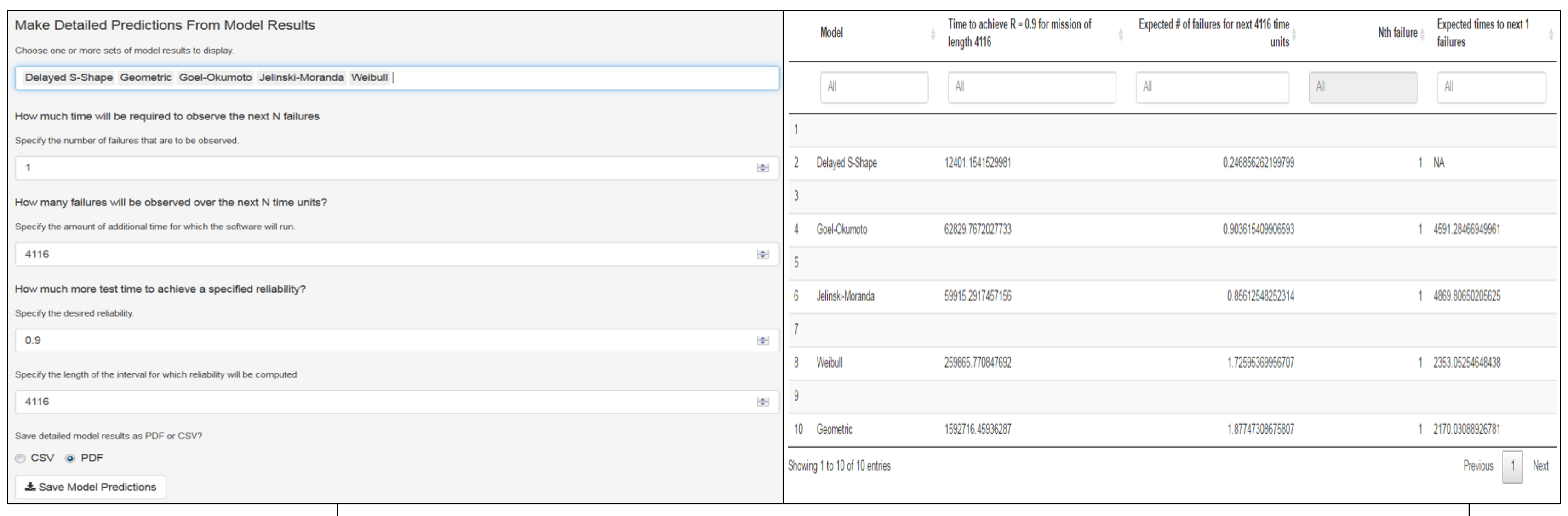
● Both ○ Points ○ Lines

Choose the type of file to save plots. Tables are saved as CSV files.

● JPEG ○ PDF ○ PNG ○ TIFF

Save

Tab 3: options and Predictions



Make Detailed Predictions From Model Results

Choose one or more sets of model results to display.

Delayed S-Shape Geometric Goel-Okumoto Jelinski-Moranda Weibull

How much time will be required to observe the next N failures

Specify the number of failures that are to be observed.

1

How many failures will be observed over the next N time units?

Specify the amount of additional time for which the software will run.

4116

How much more test time to achieve a specified reliability?

Specify the desired reliability.

0.9

Specify the length of the interval for which reliability will be computed

4116

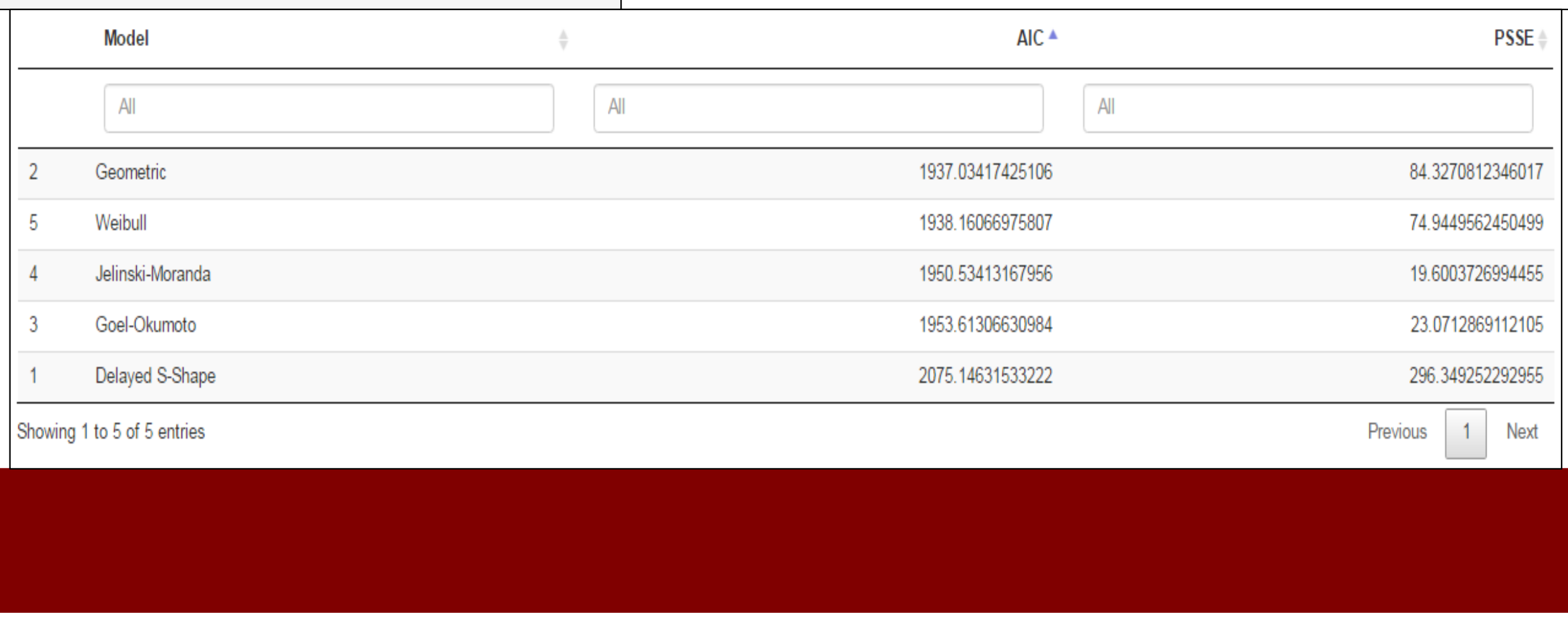
Save detailed model results as PDF or CSV?

○ CSV ● PDF

Save Model Predictions

	Model	Time to achieve R = 0.9 for mission of length 4116	Expected # of failures for next 4116 time units	Nth failure	Expected times to next 1 failures
	All	All	All	All	All
1					
2	Delayed S-Shape	12401.1541529981	0.246856262199799	1	NA
3					
4	Goel-Okumoto	62829.7672027733	0.903615409906593	1	4591.28466949961
5					
6	Jelinski-Moranda	59915.2917457156	0.85612548252314	1	4869.80650205625
7					
8	Weibull	259865.770847692	1.72595369956707	1	2353.05254648438
9					
10	Geometric	1592716.45936287	1.87747308675807	1	2170.03088926781

Showing 1 to 10 of 10 entries Previous 1 Next



	Model	AIC ▲	PSSE
	All	All	All
2	Geometric	1937.03417425106	84.3270812346017
5	Weibull	1938.16066975807	74.9449562450499
4	Jelinski-Moranda	1950.53413167956	19.6003726994455
3	Goel-Okumoto	1953.61306630984	23.0712869112105
1	Delayed S-Shape	2075.14631533222	296.349252292955

Showing 1 to 5 of 5 entries Previous 1 Next

Tab 4: Model assessment based on AIC and PSSE

Goals & Objectives

Software Failure and Reliability Assessment Tool (SFRAT)

- An open source application
- Designed for practitioner and research community
- Programmed in R and provides functionality through a Shiny graphical user interface
- Reduces the need for knowledge of the underlying statistical techniques
  - Can help contractors quantitatively assess software as part of their data collection and reporting process

Allows users to answer following questions about a software system during test

1. Is the software ready to release (has it achieved a specified reliability goal)?
2. How much more time and test effort will be required to achieve a specified goal?
3. What will be the consequences to system's operational reliability if not enough testing resources are available?

Methodology

Software reliability growth models included:

1. Failure rate models
   - Jelinski-Moranda
   - Geometric
2. Failure count models
   - Goel-Okumoto
   - Weibull
   - Delayed S-shaped

Input file format: Excel or CSV

1	FN	IF	FT
2	1	3	3
3	2	30	33
4	3	113	146
5	4	81	227
6	5	115	342
7	…	…	…

Data Formats:

- Inter-failure times - time between $(i-1)^{st}$ and i^{th} failure, defined as $t_i = (\mathbf{T}_i - \mathbf{T}_{i-1})$
- Failure times – vector of failure times, $\mathbf{T} = < t_1, t_2, \ldots, t_n >$
- Failure count data - length of the interval and number failures observed within it,
  - $< \mathbf{T}, \mathbf{K} > = < (t_1, k_1), (t_2, k_2), \ldots, (t_n, k_n) >$

SFRAT Output/Deliverables

- Trend tests
- Model rankings
- Visualization
  - Cumulative failure plot
  - Time between failure plot
  - Failure intensity plot
  - Reliability growth plot
- Predictions
  - Time to achieve reliability
  - Expected number of faults for next t time units
  - Expected time to next k failures

Conclusions and Future Research

- Open source application to promote collaboration among
  - Members of software reliability research community
  - Users from industry and government organizations
- Application architecture enables integration of models from research literature
- Future research will expand architecture to enable models for other stages of SDLC

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Contacts/References

Tool and relevant resources are available at

http://sasdlc.org/lab/

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