A Tour of JMP Reliability Platforms and Bayesian Methods for Reliability Data

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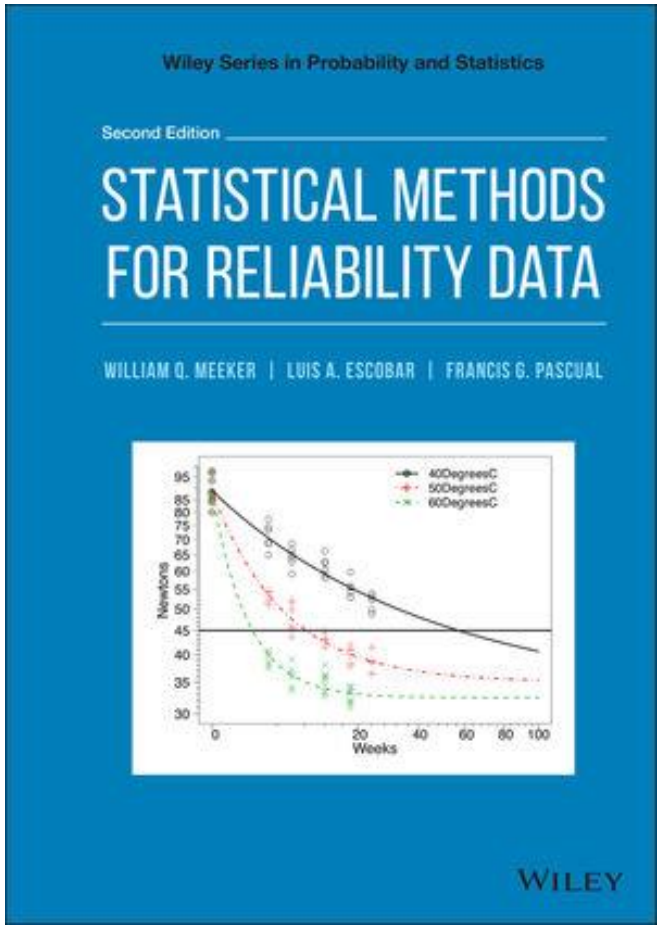
JMP Reliability Platforms – History & Status

- 15+yrs of collaboration with William Meeker.
- JMP now supports a wide range of reliability related products.



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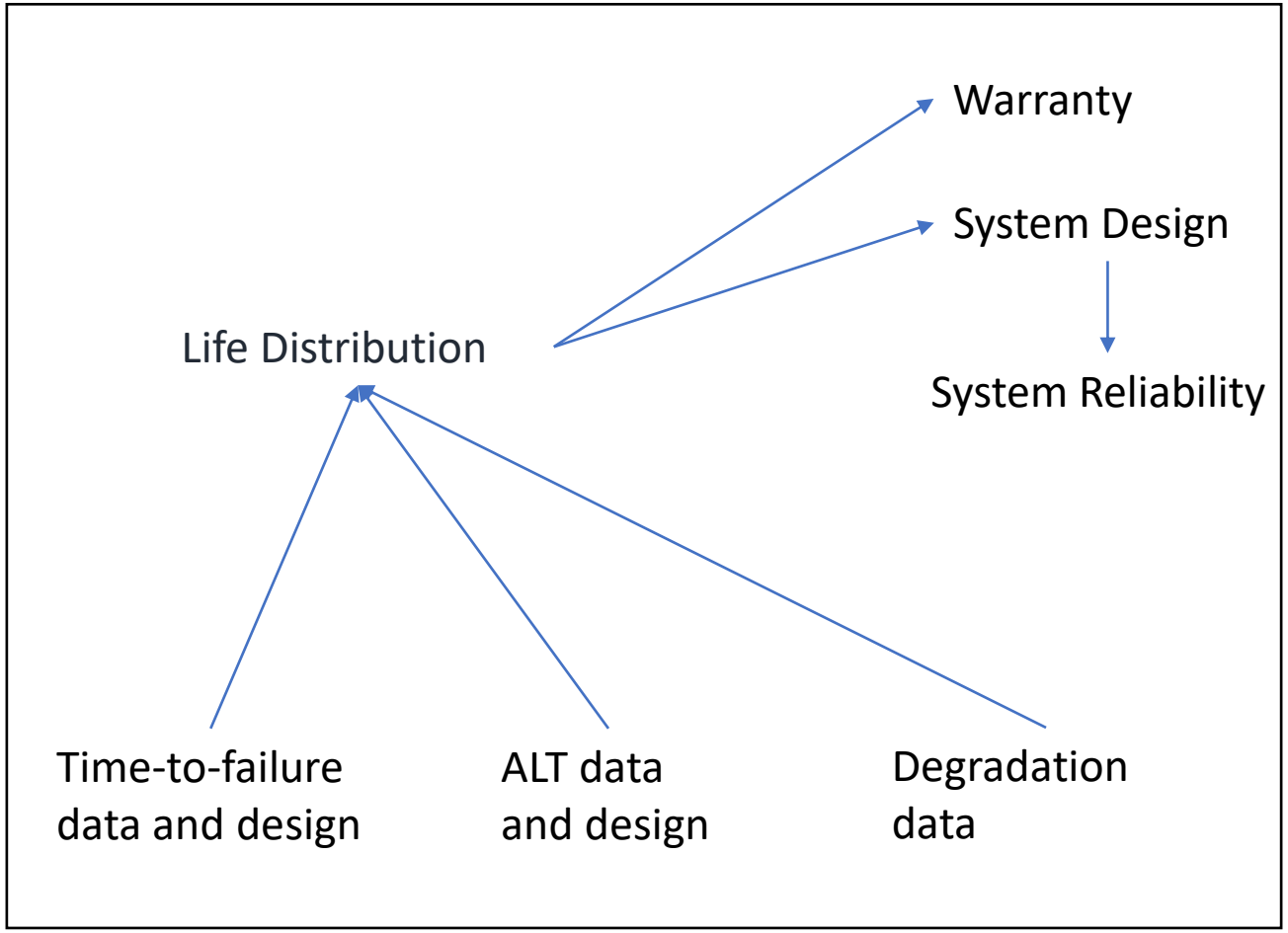
JMP Reliability Products for Non-repairable

- Life Distribution
- Survival
- Reliability Forecast
- Fit Life by X
- Parametric Survival
- Cumulative Damage
- Degradation
- Destructive Degradation
- Test Plan
- Demonstration Plan
- ALT Design
- Reliability Block Diagram



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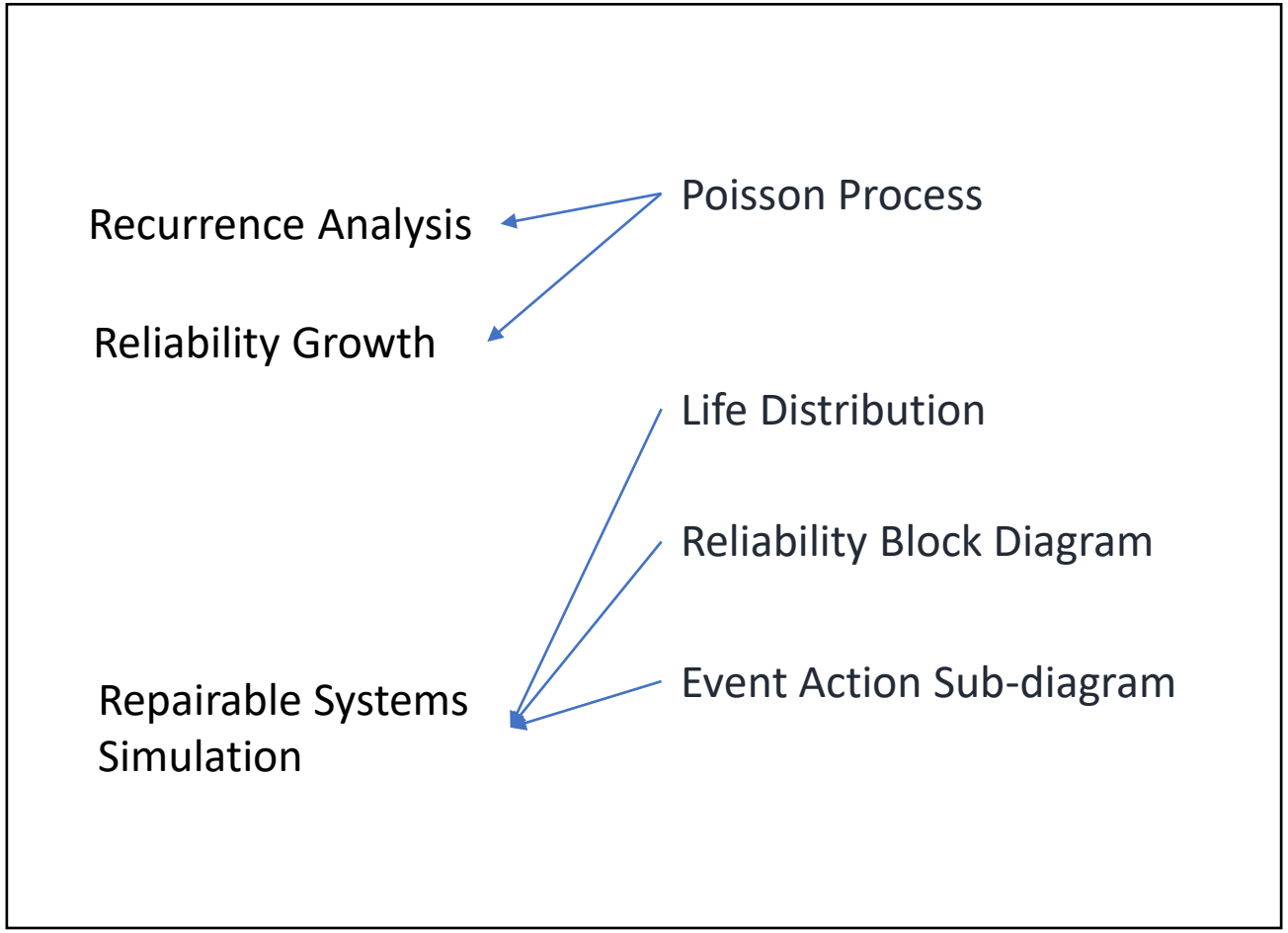
JMP Reliability Products for Repairable

- Recurrence Analysis
- Reliability Growth
- Repairable Systems Simulation



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Data Types & Platforms

Objective	Platform Name(s)	Applicable Circumstance
Obtain Failure Probability of a System	Life Distribution	Time-to-event data
	Fit Life by X	Time-to-event data with one time-invariant factor
	Cumulative Damage	Time-to-event data with one time-varying factor
	Parametric Survival	Time-to-event with multiple time-invariant Factors
	Repeated Measures Degradation	Degradation data from non-destructive experiments or observation
	Destructive Degradation	Degradation data from destructive experiments or observation
Track Reliability of a Process	Recurrence Data Analysis	Counting process data with multiple covariates
	Reliability Growth	Counting process data for project development process.

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Models within Platforms

Platform	Models
Life Distribution	Numerous distribution types Competing Cause Mixture
Fit Life by X	Numerous distribution types and different acceleration mechanisms
Cumulative Damage	
Repeated Measures Degradation	Different degradation mechanisms
Destructive Degradation	Different degradation mechanisms
Recurrence Data Analysis	Different point process types
Reliability Growth	Different application-oriented point process types

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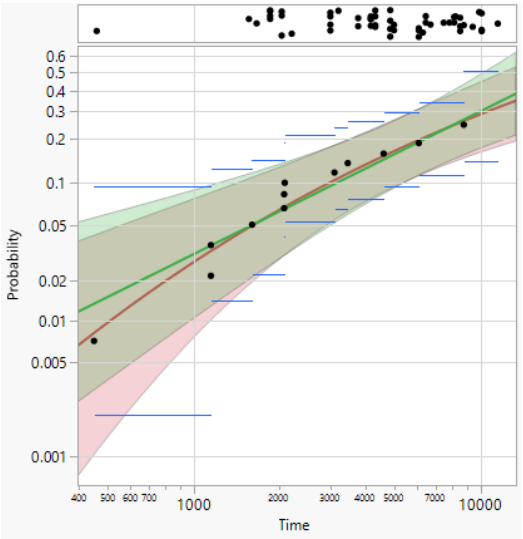

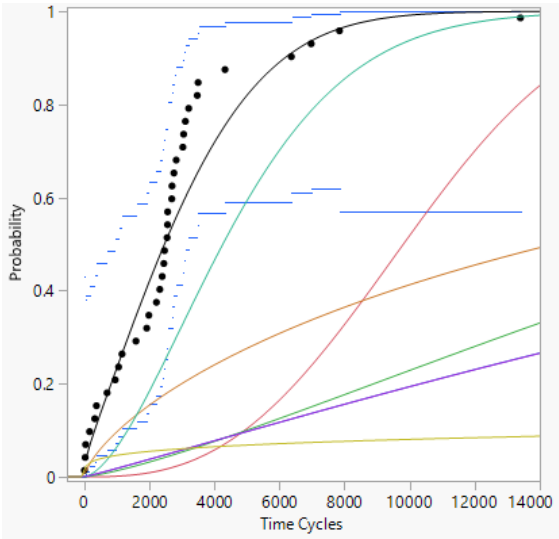

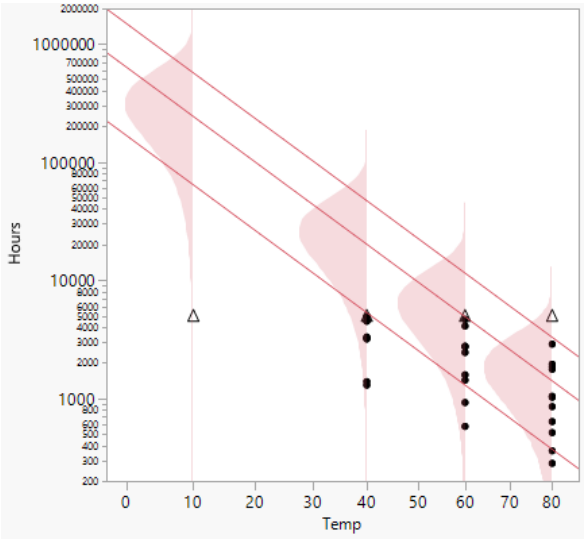

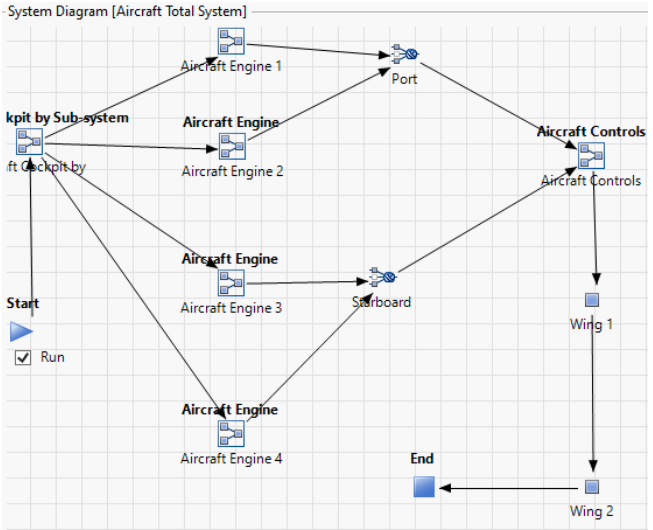

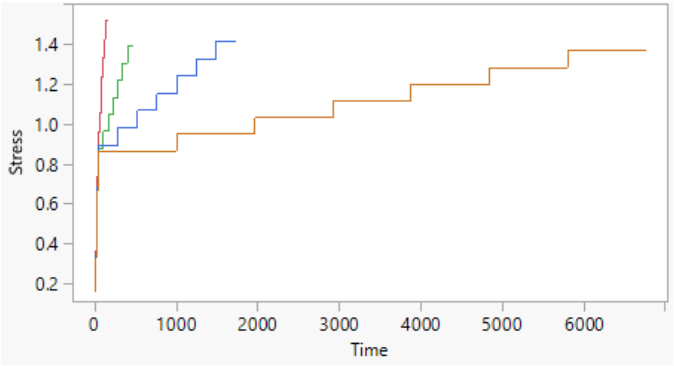

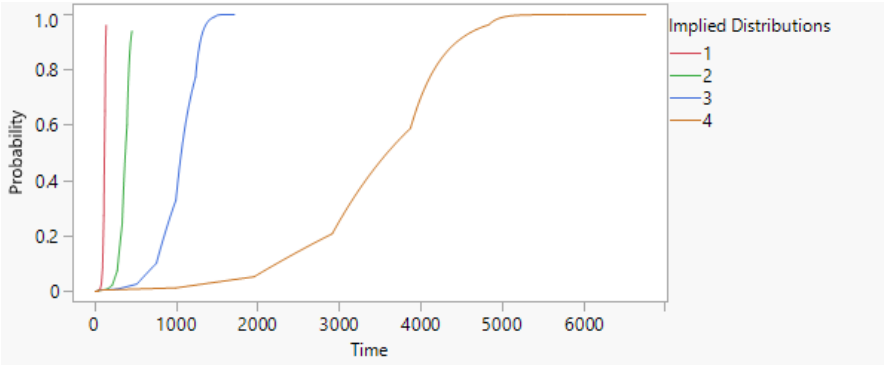

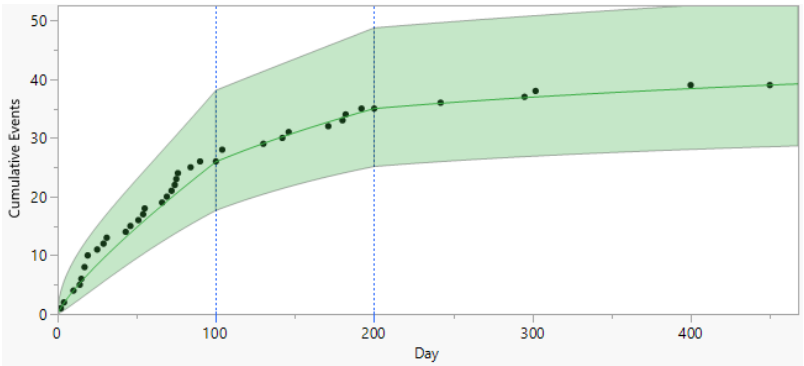

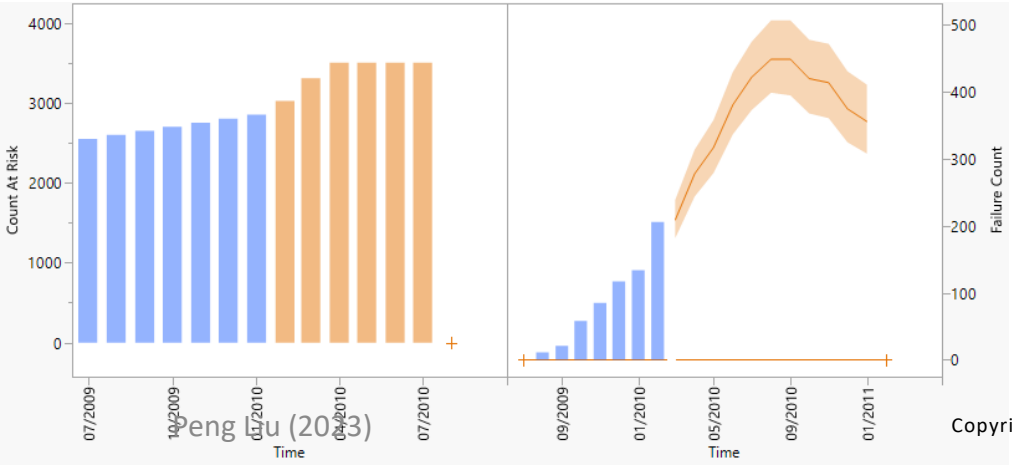

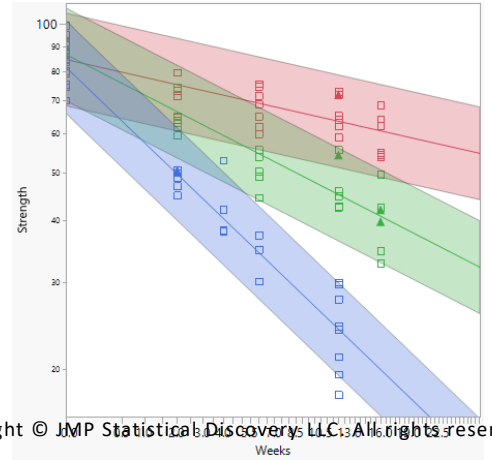

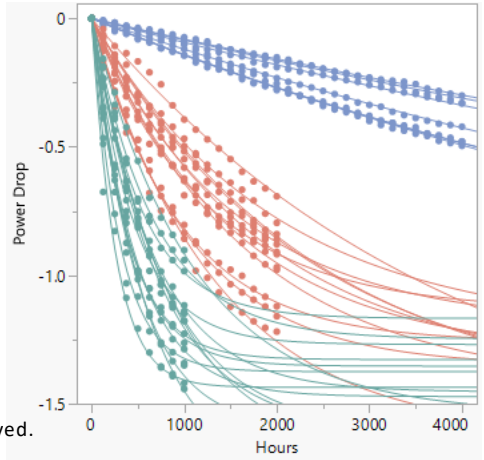

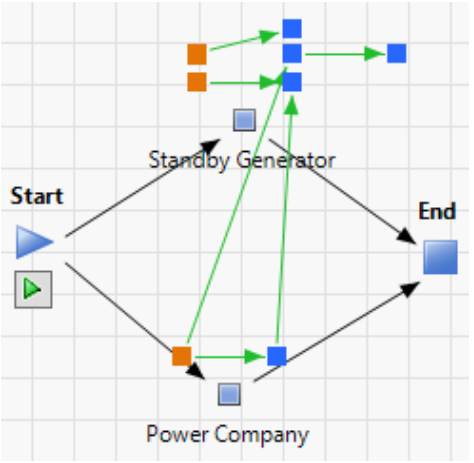

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Bayesian Methods for Reliability Data (1)

- Reliability data can be scarce. We need to observe failure events, but
  - Sample size can be small.
  - Experiment duration can be short.
  - Subjects can be too reliable, so duration will be relatively too short.
  - When data are scarce, conclusion on reliability can be unrealistically conservative.
- Bayesian Methods can incorporate additional information
  - If the information is trustworthy, and conclusion on reliability can be more realistic.
- A challenge is to have trustworthy information.

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Bayesian Methods for Reliability Data (2)

- Reliability models can be challenging, due to non-linearity.
  - Challenging to fit using traditional statistical inference methods.
  - There are competing traditional statistical inference methods, and it is difficult to justify or evaluate their differences.
- Bayesian Methods provides a unified approach. No ambiguity.
  - And it is flexible, without the need to invent new wheels for new problems.
- A challenge is that it requires computing power and has steep learning curve.

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Tutorial Plan

- Fundamental Consensus on Censored Data Formats in JMP
- Bayesian Method in Life Distribution
  - Rocket Motor
- Bayesian Method in Fit Life by X
  - IC Device
- Bayesian Method in Repeated Measures Degradation
  - Alloy-A
  - Device B

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Consensus on Data Formats

Censored Data Formats in JMP

- Four Types: Failure, Right Censored, Left Censored, Interval Censored
- Two Formats: Right-Censor Format. Two-column Format.

	Time Cycles
1	11
2	2223
3	4329
4	3112
5	13403
6	6367
7	2451
8	381
9	1062
10	1594

	Time	Censor
1	450	Failed
2	460	Censored
3	1150	Failed
4	1150	Failed
5	1560	Censored
6	1600	Failed
7	1660	Censored
8	1850	Censored
9	1850	Censored
10	1850	Censored

	start time	end time	count
1	•	6	6
2	6	12	2
3	24	48	2
4	24	•	1
5	48	168	1
6	48	•	839
7	168	500	1
8	168	•	150
9	500	1000	2
10	500	•	149

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Censored Data Formats in JMP

- Failure, Right Censored, Left Censored, Interval Censored
  - (A) Failure: failed at an exact time.
  - (B) Right censored at time t: failed after time t.
  - (C) Left censored at time t: failed before time t.
  - (D) Interval censored between t_L and t_R: failed between time t_L and t_R

- In the case of time to event, $t > 0$, Failure, Left Censored, and Interval Censored all carry some information about failure time to different extents of measurement accuracy.

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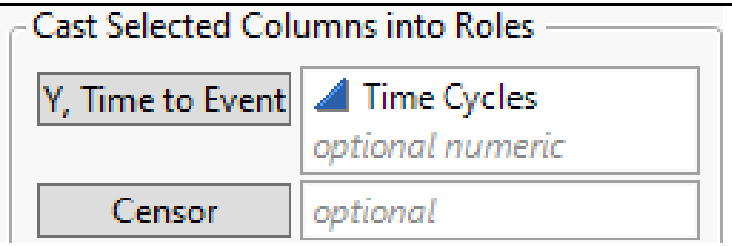
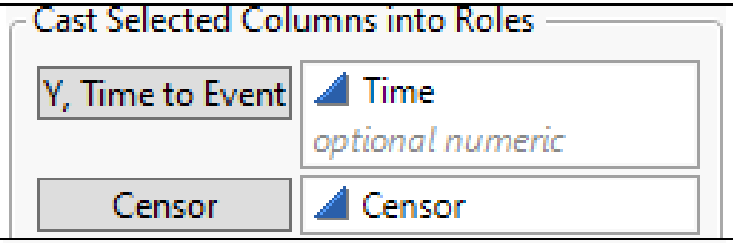
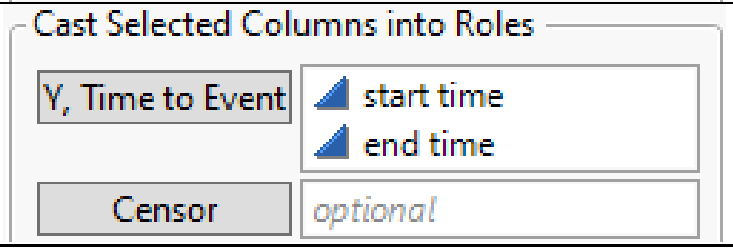
Censored Data Formats and Launch Dialog

Specify launch dialog for exact failure data.	
Specify launch dialog for right-censored data with a Censor indicator column.	
Specify launch dialog for arbitrary censoring schemes with two-column format data.	

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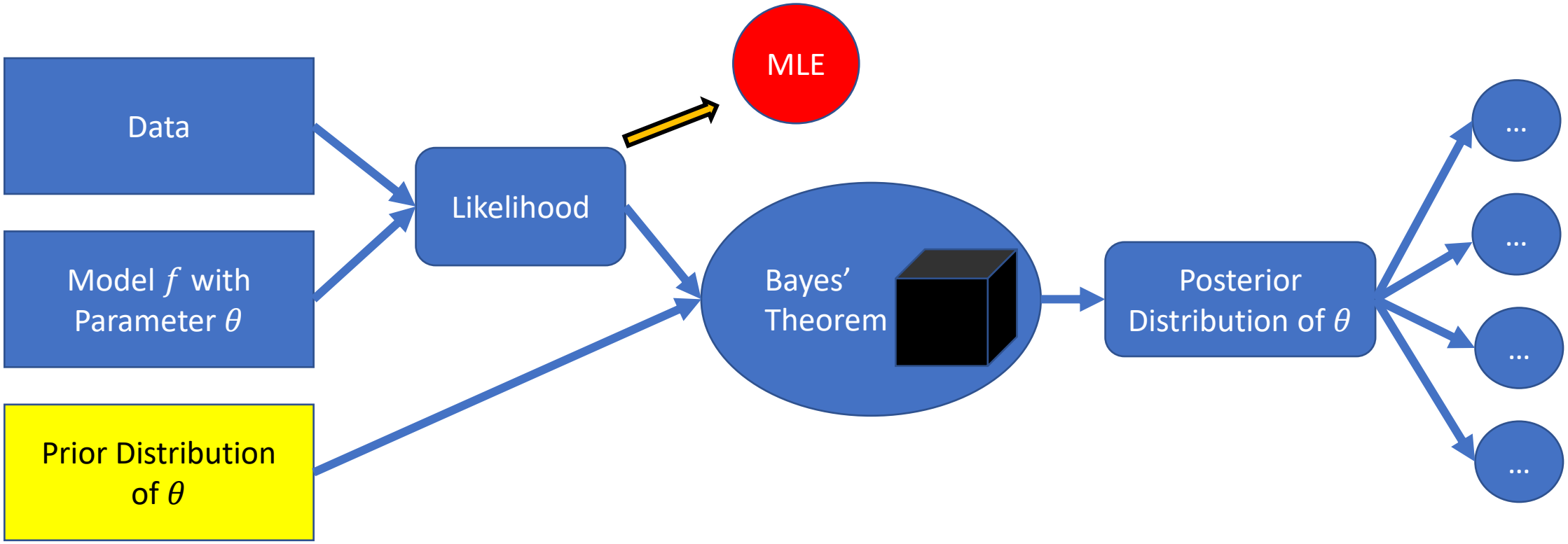
Bayesian Method



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Bayesian Method – Inside the Blackbox

- Something simple: Rejection Method.
- The well established: BUGS; Metropolis-Hastings Algo.
- Something new: Hamiltonian Monte Carlo.
- … a lot of variations

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Bayesian Method – In JMP Reliability Prod.

- Life Distribution. (Rejection Method & MH Method)
- Fit Life by X. (Rejection Method & MH Method)
- Repeated Measures Degradation. (MH Method)

- Why still use Rejection Method?
  - Rejection rate is not always high, especially failures are scarce.
  - Rejection method is the benchmark for testing other methods.

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Tutorial by Examples

- Rocket Motor
- IC Device
- Alloy A
- Device B

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Conclusion

- JMP reliability products are comprehensive.
- JMP reliability products are mature.
- The implemented approaches for analyzing reliability data are rigorous, from the statistical interference perspective.
- The Bayesian methods implemented in JMP reliability products are at the frontier in research.
- The Bayesian methods implemented in JMP reliability products are accessible, in terms of use and explanation.

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Thank you!

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