FORELESNING 12
Våren 2004
22. april

TMA4275 LEVETIDSANALYSE

Bo Lindqvist

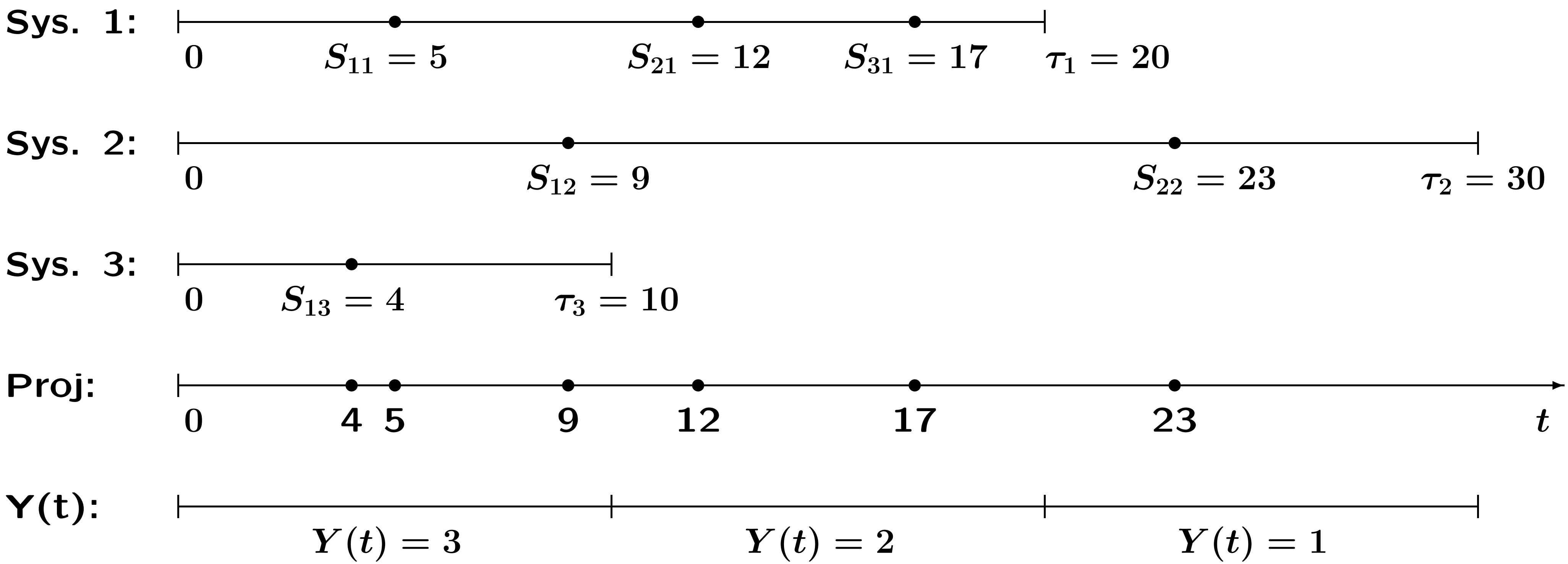
Institutt for matematiske fag

NTNU

bo@math.ntnu.no

http://www.math.ntnu.no/~bo/

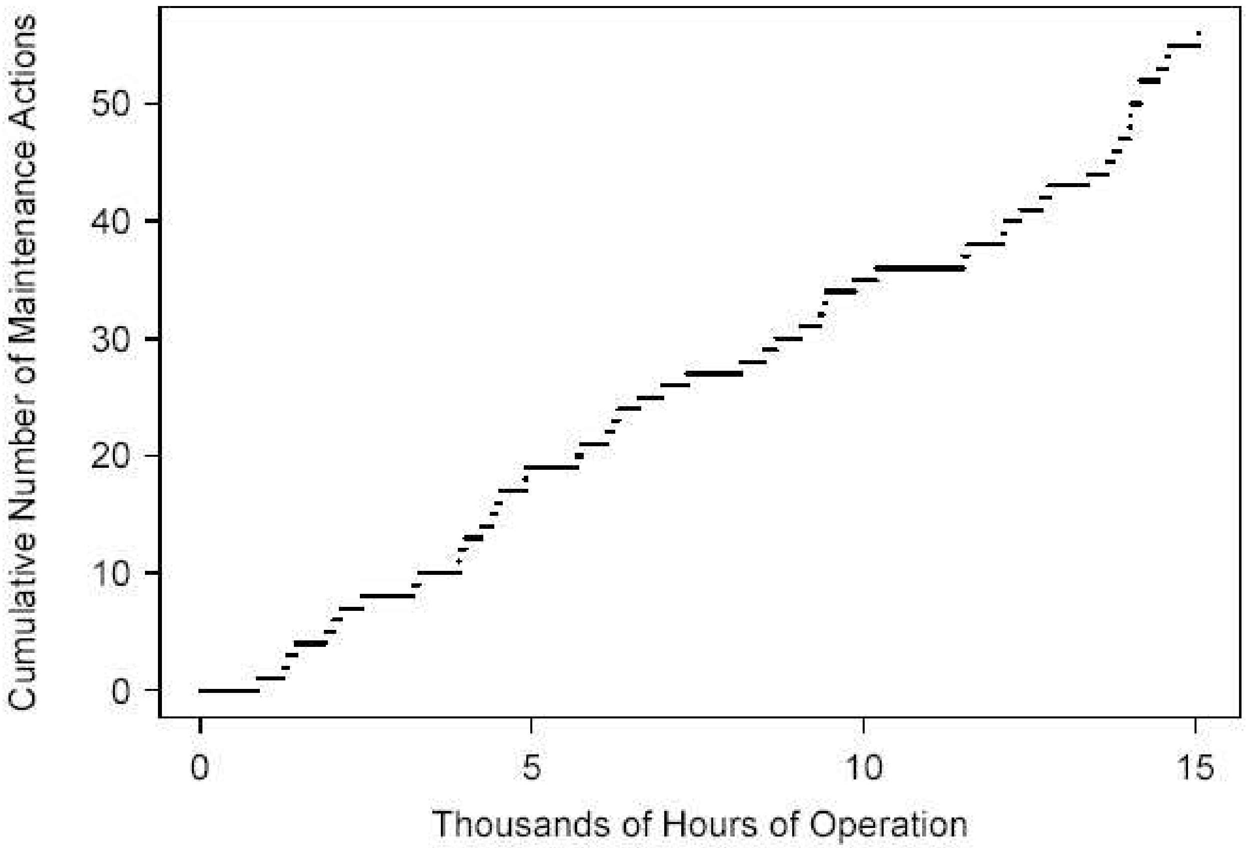
SIMPLE EXAMPLE WITH THREE SYSTEMS



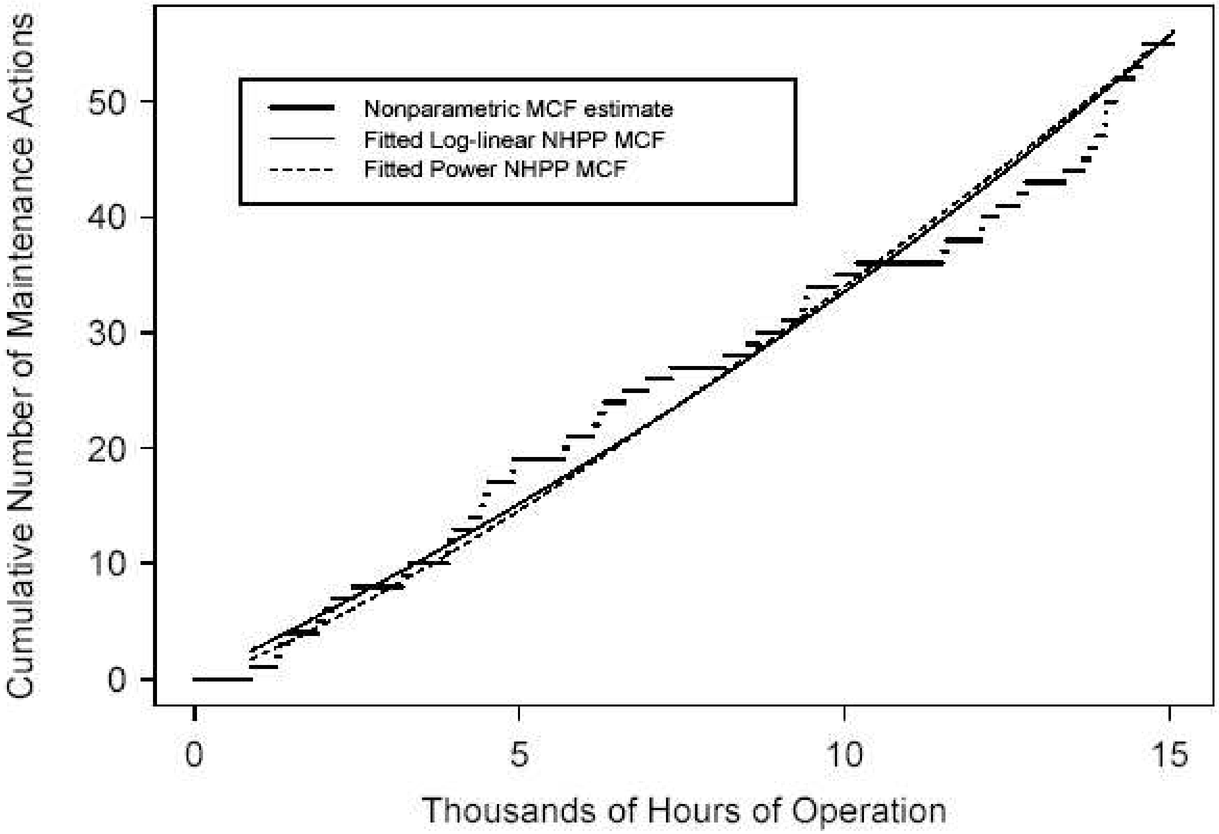
Times of Unscheduled Maintenance Actions for a USS Grampus Diesel Engine

- Unscheduled maintenance actions caused by failure of imminent failure.
- Unscheduled maintenance actions are inconvenient and expensive.
- Data available for 16,000 operating hours.
- Data from Lee (1980).
- Is the system deteriorating (i.e., are failures occurring more rapidly as the system ages)?
- Can the occurrence of unscheduled maintenance actions be modeled by an HPP?

Cumulative Number of Unscheduled Maintenance Actions Versus Operating Hours for a USS Grampus Diesel Engine
Lee (1980)



Cumulative Number of Unscheduled Maintenance Actions Versus Operating Hours with Power and Loglinear NHPP Models for a USS Grampus Diesel Engine



Results of Fitting NHPP Models to the USS Grampus Diesel Engine Data

- Both models seem to fit the data very well.

- For the power recurrence rate model, $\widehat{\beta}$=1.22 and $\widehat{\eta}$ =0.553.

- For the loglinear recurrence rate model, $\widehat{\gamma}_0$=1.01 and $\widehat{\gamma}_1$ =.0377.

- Times between recurrences are consistent with a HPP:

  - the Lewis-Robinson test gave $Z_{\text{LR}} = 1.02$ with p-value $p = .21$.

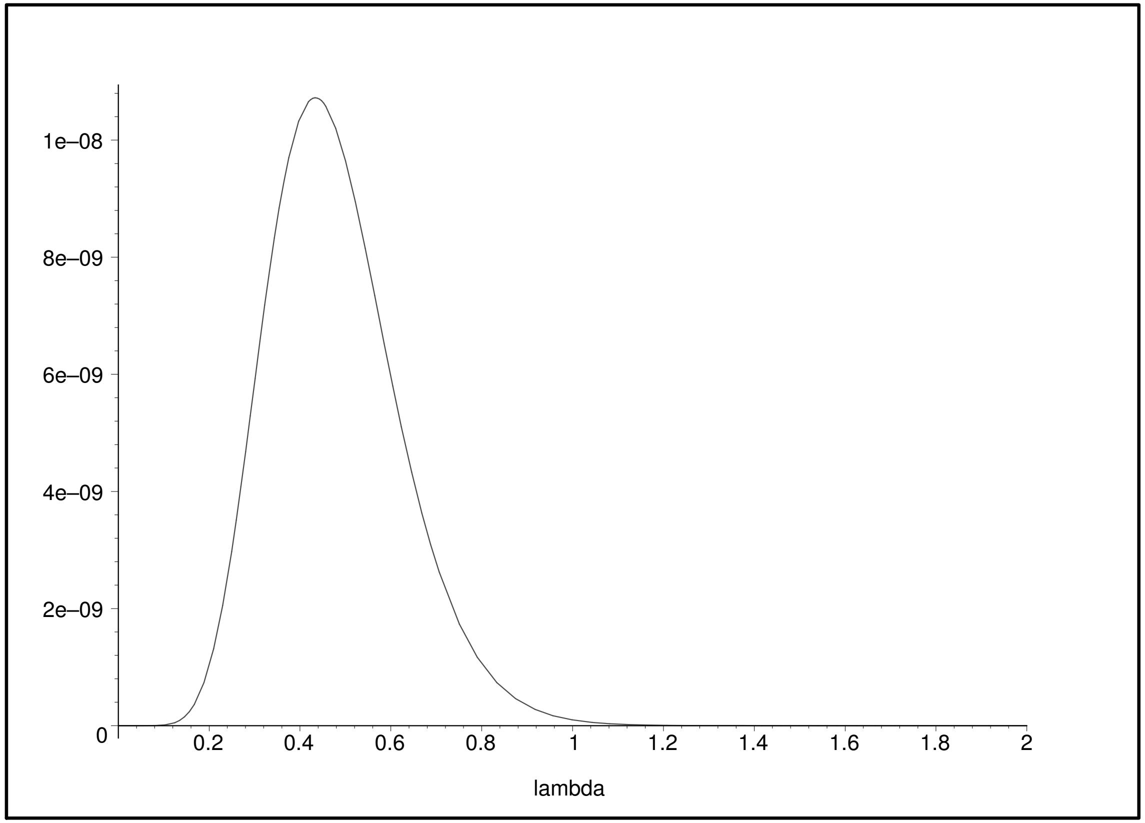
  - the MIL-HDBk-189 test gave $X^2_{\text{MHB}} = 92$ with p-value $p = .08$.

Life testing of $n = 13$ airplane components (Mann and Fertig, 1976), censored after failure number $r = 10$ (Type II-censoring), resulted in:

j	Time (Y_j)	Censor
1	0,22	1
2	0,50	1
3	0,88	1
4	1,00	1
5	1,32	1
6	1,33	1
7	1,54	1
8	1,76	1
9	2,50	1
10	3,00	1
11	3,00	0
12	3,00	0
13	3,00	0

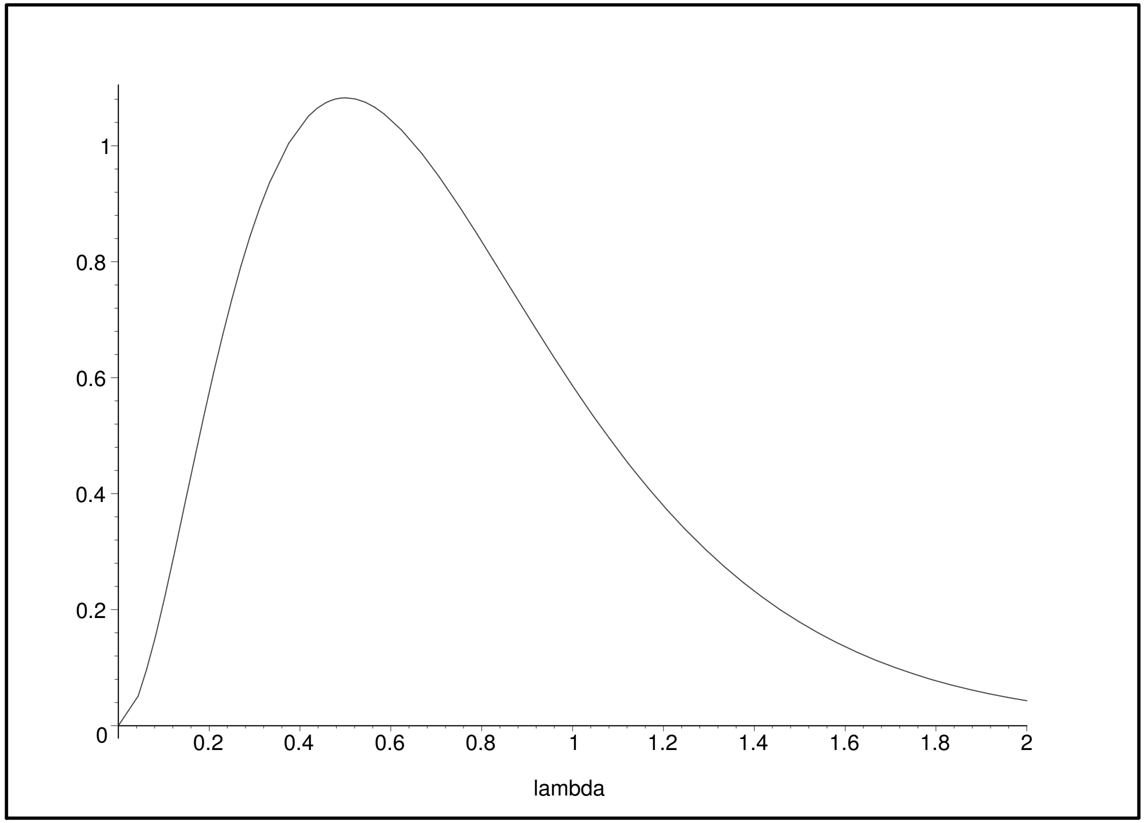
Let the model be that $T \sim$ eksp(λ), i.e. the likelihood-function is

$$L(\lambda|\text{data}) = \lambda^r e^{-\sum_{j=1}^{n} y_j} = \lambda^{10} e^{-23.05}$$



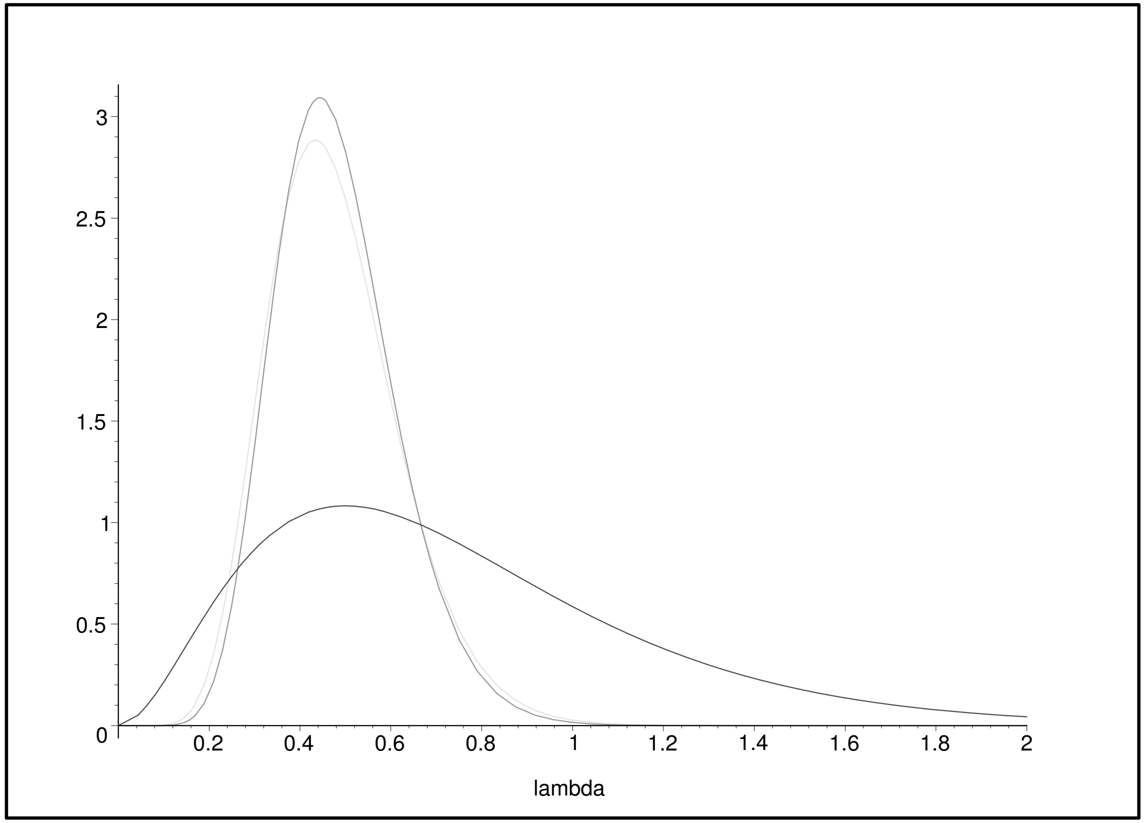
Likelihood-function for airplane component data

MLE: $\hat{\lambda} = 0.434$



Prior distribution for λ in airplane component data, $\Lambda \sim$ Gamma$(3, 4)$

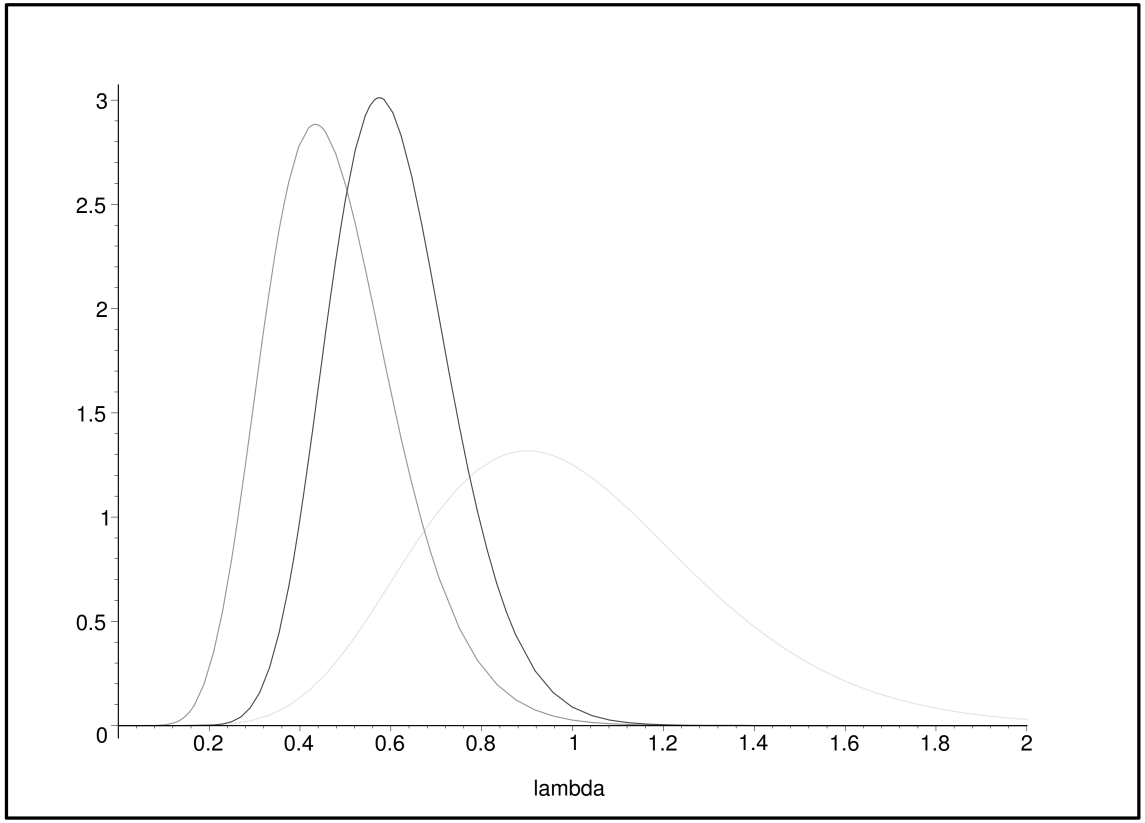
$$\boldsymbol{E(\Lambda) = 0.75,\ SD(\Lambda) = 0.43320}$$



Prior distribution (”lowest”), Likelihood-function (normalized to density, ”second highest”) and Posterior distribution (”highest”) for λ in airplane component data.

Posterior maximum is for $\lambda = 0.444$

Posterior expectation, i.e. Bayes-estimate is $\hat{\lambda}_B = 0.481$



Alternative prior distribution (Gamma(10,10), "lowest"), Likelihood function (normalized to density, "second highest") and Posterior distribution ("highest") for λ in airplane component data.

Posterior maximum is now for $\lambda = 0.575$.

Posterior expectation, i.e. Bayes-estimate is now $\hat{\lambda}_B = 0.6051$