

# Package ‘FaultTree’

January 20, 2025

**Version** 1.0.1

**Date** 2023-8-26

**Title** Fault Trees for Risk and Reliability Analysis

**Description** Construction, calculation and display of fault trees. Methods derived from Clifton A. Ericson II (2005, ISBN: 9780471739425) <DOI:10.1002/0471739421>, Antoine Rauzy (1993) <DOI:10.1016/0951-8320(93)90060-C>, Tim Bedford and Roger Cooke (2012, ISBN: 9780511813597) <DOI:10.1017/CBO9780511813597>, Nikolaos Limnios, (2007, ISBN: 9780470612484) <DOI:10.1002/9780470612484>.

**License** GPL (>= 3)

**Copyright** copyright (c) OpenReliability.org 2015-2022

**URL** <http://www.openreliability.org/fault-tree-analysis-on-r/>

**LazyLoad** yes

**Imports** Rcpp (>= 0.12.4)

**LinkingTo** Rcpp, RcppArmadillo

**Author** David Silkworth [aut],  
Jacob Ormerod [cre],  
OpenReliability.org [cph]

**Maintainer** Jacob Ormerod <jake@openreliability.org>

**NeedsCompilation** yes

**Suggests** magrittr

**Repository** CRAN

**Date/Publication** 2023-08-26 17:00:05 UTC

## Contents

FaultTree-package . . . . .	2
addActive . . . . .	3
addDemand . . . . .	4
addDuplicate . . . . .	5
addExposed . . . . .	6

addHouse . . . . .	8
addLatent . . . . .	9
addLogic . . . . .	10
addProbability . . . . .	12
addUndeveloped . . . . .	13
applyCollapse . . . . .	14
cutsets . . . . .	15
ftree.calc . . . . .	16
ftree.make . . . . .	17
ftree2bdd . . . . .	19
ftree2html . . . . .	19
ftree2table . . . . .	20
hierarchyDF2json . . . . .	21
parameter_conversion . . . . .	22
pc . . . . .	23
prob2lam . . . . .	24
probability . . . . .	25
tagconnect . . . . .	25
test.ftree . . . . .	26
<b>Index</b>	<b>28</b>

---

FaultTree-package      *Fault Trees for Risk and Reliability Analysis*

---

## Description

A package for constructing, calculating and displaying fault trees.

## Introduction

**FaultTree** provides functions for building tree structures as dataframe objects. The fault tree incorporates logic nodes (primarily AND and OR) which process input and may direct output "upwards" through the tree structure. Data is entered through component entries. Component event entries may be active (failures immediately revealed) or dormant (failures remain hidden until activation or inspection). The fault tree may also accept pure probability or pure demand input components.

## Author(s)

David J. Silkworth

Maintainer: Jacob T. Ormerod <jake@openreliability.org>

## References

- Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.
- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

---

addActive	<i>Add an Active Component Event</i>
-----------	--------------------------------------

---

## Description

Modifies an existing fault tree with the addition of an active component event.

## Usage

```
addActive(DF, at, mttf, mtrr, display_under=NULL, tag="", label="",
name="", name2="", description="")
```

## Arguments

DF	A fault tree dataframe such as returned from <code>ftee.make</code> or related <code>add...</code> functions.
at	The ID of the parent node for this addition.
mttf	The mean time to failure. It is the user's responsibility to maintain constant units of time.
mtrr	The mean time to repair (restore). It is the user's responsibility to maintain constant units of time.
display_under	Optionally, the ID of a sibling event under an OR gate for vertical alignment of the component node in the graphic display.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of <code>label</code> in <code>ftee.make</code> defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for the basic event.

**Value**

Returns the input fault tree dataframe appended with an entry row for the defined component event.

**References**

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons

Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission

Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA

Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="or")
mytree <- addActive(mytree, at=1, mttf=3, mtr=12/8760,name="pump failure")
```

---

addDemand

*Add a Pure Demand Event*

---

**Description**

Modifies an existing fault tree with the addition of a pure demand event.

**Usage**

```
addDemand(DF, at, mttf, tag="", label="", name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
at	The ID of the parent node for this addition.
mttf	The mean time interval to events. It is the user's responsibility to maintain constant units of time.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of label in ftree.make defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for the resultant event.

**Value**

Returns the input fault tree dataframe appended with an entry row for the defined component event. Note that when a pure demand is used in combination under an AND gate, the result will contain only a conditional fail rate.

**References**

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
 O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
 Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission  
 Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA  
 Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="and")
mytree <- addDemand(mytree, at=1, mttf=1, name="power interruption")
```

---

addDuplicate	<i>Add a duplicated (repeated) event or entire branch to a fault tree.</i>
--------------	--

---

**Description**

Modifies an existing fault tree with the addition of the repeated nodes.

**Usage**

```
addDuplicate(DF, at, dup_id=NULL, dup_of=NULL, display_under=NULL,
collapse=FALSE)
```

**Arguments**

- |               |   |
|---------------|---|
| DF            | A fault tree dataframe such as returned from ftree.make or related add... functions.  |
| at            | The ID of the parent node for this addition.  |
| dup_id        | The ID or tag name of a component event or root node of a branch to be repeated in a fault tree. Must provide either dup_id or dup_of.                              |
| dup_of        | Alternative argument for the ID or tag name of a component event or root node of a branch to be repeated in a fault tree. If dup_id is provided, dup_of is ignored. |
| display_under | Optionally, the ID of a sibling event under an OR gate for vertical alignment of only component nodes (MOE, not MOB) in the graphic display.                        |
| collapse      | A logical to determine whether a branch should be collapsed on initial view.  |

## Details

This function is used to replicate the source event(s), not just copy for a similar item. Both the source and replicated nodes are notated in a MOE column of the fault tree dataframe. This notation will be used by future minimal cut set determination. Additionally, future editing functions can be notified and likely blocked on these items.

## Value

Returns the input fault tree dataframe appended with a entry row(s) for the defined component event.

## References

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers
- Ericson II, Clifton A. (2011) Fault Tree Analysis Primer CreateSpace Inc.

## Examples

```
mytree <-ftree.make(type="or")
mytree <- addLogic(mytree, at=1, type= "and", name="A and B failed")
mytree <- addProbability(mytree, at=2, prob=.01, name="switch A failure")
mytree <- addProbability(mytree, at=2, prob=.01, name="switch B failure")
mytree <- addLogic(mytree, at=1, type= "and", name="A and C failed")
mytree <- addDuplicate(mytree, at=5, dup_id=3)
mytree <- addProbability(mytree, at=5, prob=.01, name="switch C failure")
```

---

addExposed

*Add a Time Dependant, Non-Repairable, Event*

---

## Description

Adds a basic component event to a fault tree in which probability of failure is defined by a probability distribution and exposure time.

## Usage

```
addExposed(DF, at, mttf, dist="exponential", param=NULL, display_under=NULL,
tag="", exposure=NULL, label="", name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from <code>ftee.make</code> or related <code>add...</code> functions.
at	The ID or tag name of the parent node for this addition.
mttf	The mean time to failure. It is the user's responsibility to maintain constant units of time.
dist	The probability distribution to be used for defining probability of failure from <code>mttf</code> , and a possible extra parameter. Options for "exponential" and "weibull" have been implemented.
param	A vector containing <code>shape</code> and <code>time_shift</code> for weibull exposed events in that order.
display_under	Optionally, the ID of a sibling event under an OR gate for vertical alignment of the component node in the graphic display.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
exposure	This is to be a seldom-used override of system mission time applicable only to exponentially exposed events.
label	An identifying string for the logic gate. Use of <code>label</code> in <code>ftee.make</code> defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for this probability.

**Details**

The lambda for exponential definition is taken as  $1/mttf$ , which is the value stored in CFR for the tree node. Weibull distributions have a mean, which differs from the classical scale parameter by a factor determined as  $\gamma(1+1/shape)$ . The weibull scale is determined from the value stored in CFR (as  $1/mttf$ ) for the tree node. Additional parameters to fully define the specific distribution of expected failure times are the `shape` and any `time_shift`.

**Value**

Returns the input fault tree dataframe appended with an entry row for the defined failure event.

**References**

- Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.
- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mission_time<-0.5
mytree <-ftree.make(type="or", name="6-month task", name2="incomplete")
mytree <- addExposed(mytree, at=1, mttf=3, name="pump fails",
  name2="before completion")
```

---

 addHouse

---

*Add a Given Condition*


---

**Description**

Modifies an existing fault tree with the addition of a 'house' element. House elements signify some underlying condition and can only have probability of 1 (True) or 0 (False). They have traditionally been added to fault trees for clarity of presentation only.

**Usage**

```
addHouse(DF, at, prob=1, tag="", label="", name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
at	The ID of the parent node for this addition.
prob	A probability value of 1 or 0
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of label in ftree.make defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for this condition.

**Value**

Returns the input fault tree dataframe appended with an entry row for the defined house element.

**References**

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
 O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
 Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission  
 Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA  
 Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers



**Examples**

```
mytree <-ftree.make(type="and", name="Pump Function", name2="Failed")
mytree<-addActive(mytree,at=1,mttf=3,mtr=12/8760, name="Pump")
mytree <- addHouse(mytree, at=1, prob=1, name="Pump Function", name2="Required")
```

---

addLatent

*Add a Latent Component Event*


---

**Description**

Modifies an existing fault tree with the addition of a latent component event.

**Usage**

```
addLatent(DF, at, mttf, mtr=NULL, inspect=NULL, risk="mean",
display_under=NULL, tag="", label="",
name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
at	The ID of the parent node for this addition.
mttf	The mean time to failure. It is the user's responsibility to maintain constant units of time.
mtr	The mean time to repair (restore). This should only be provided when system remains at risk, while repair is in progress, as it modifies probability by factor "pzero". It is the user's responsibility to maintain constant units of time.
inspect	The time interval between inspections for the dormant component. (It will be possible upon future development to enter the string for the named inspection dataframe object. In this case the inspection object will be read to get the inspection interval. An inspection object must be a dataframe with interval and duration columns. If a positive duration value other than zero is found it is taken that the system is at risk during the time of inspection. An unavailable probability calculated as duration/(interval+duration) will be added to the fractional downtime.
risk	An opportunity to utilize the "max" risk probability occurring at the end of inspection duration.
display_under	Optionally, the ID of a sibling event under an OR gate for vertical alignment of the component node in the graphic display.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of label in ftree.make defines the convention for rest of tree construction.

name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for the basic event.

**Value**

Returns the input fault tree dataframe appended with an entry row for the defined component event.

**References**

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
 O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
 Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission  
 Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA  
 Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="and")
mytree <- addLatent(mytree, at=1, mttf=5,mttr=12/8760,inspect=1/26, name="e-gen set fails")
```

---

addLogic	<i>Add a Logic Gate</i>
----------	-------------------------

---

**Description**

Modifies an existing fault tree with the addition of a logic gate.

**Usage**

```
addLogic(DF, type, at, reversible_cond=FALSE, cond_first=TRUE, human_pbf=NULL,
vote_par=NULL, tag="", label="", name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
type	A string signifying the type of logic to be applied. Implemented gate types "or","and","inhibit","conditional" (or "cond"), vote, and "alarm" have been implemented.
at	The ID or tag name of the parent node for this addition.

reversible_cond	A boolean value used only by the conditional gate type indicating whether repair of the input condition is viable to the model.
cond_first	A boolean signifying whether the first child to an INHIBIT, ALARM, or PRIORITY logic gate should be taken as the condition. Alternatively, if FALSE, the second child will be taken as a condition. This is primarily a graphic display issue.
human_pbf	A probability of failure for a human to respond as needed to an alarm. This value is only used by the alarm gate.
vote_par	A vector of vote parameters as c(k,n) for k of n voting.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of label in ftree.make defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for the resultant event.

### Value

Returns the input fault tree dataframe appended with an entry row to accept the result of the logic calculation.

### References

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

### Examples

```
mytree <-ftree.make(type="cond", reversible_cond=TRUE, name="power outage")
mytree<-addLogic(mytree, at=1, type="and", name="neither emergency", name2="generator operable")
mytree<-addLatent(mytree, at=2, mttf=5,mttr=12/8760,inspect=1/26, name="e-gen set fails")
mytree<-addLatent(mytree, at=2, mttf=5,mttr=12/8760,inspect=1/26, name="e-gen set fails")
mytree <- addDemand(mytree, at=1, mttf=1, name="incomming power", name2="interruption")
```

---

addProbability      *Add a Pure Probability*

---

### Description

Modifies an existing fault tree with the addition of a pure probability.

### Usage

```
addProbability(DF, at, prob, display_under=NULL, tag="",
label="", name="", name2="", description="")
```

### Arguments

DF	A fault tree dataframe such as returned from <code>ftee.make</code> or related <code>add...</code> functions.
at	The ID of the parent node for this addition.
prob	A probability value $>0$ && $<1$
display_under	Optionally, the ID of a sibling event under an OR gate for vertical alignment of the component node in the graphic display.
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of <code>label</code> in <code>ftee.make</code> defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for this probability.

### Value

Returns the input fault tree dataframe appended with an entry row for the defined probability.

### References

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission  
Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA  
Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="and", name="common cause failure", name2="of redundant pumps")
mytree<-addActive(mytree,at=1,mttf=3,mttr=12/8760, name="Pump")
mytree <- addProbability(mytree, at=1, prob=.05, name="common cause", name2="beta factor")
```

---

addUndeveloped	<i>Enter a Probability for an Undeveloped Event</i>
----------------	---

---

**Description**

Modifies an existing fault tree with the addition of an undeveloped probability.

**Usage**

```
addUndeveloped(DF, at, prob=0, tag="", label="",
name="", name2="", description="")
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
at	The ID or tag name of the parent node for this addition.
prob	A probability value $\geq 0$ && $< 1$
tag	A very short identifying string (typically 5 characters or less) uniquely identifying a basic event for minimal cutset evaluation
label	An identifying string for the logic gate. Use of label in ftree.make defines the convention for rest of tree construction.
name	A short identifying string (typically less than 24 characters)
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for this probability.

**Value**

Returns the input fault tree dataframe appended with an entry row for the undeveloped probability.

**References**

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission  
Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA  
Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="and", name="pumping failures")
mytree<-addActive(mytree,at=1,mttf=3,mttr=12/8760, name="Pump Mechanical", name2="Failures")
mytree <- addUndeveloped(mytree, at=1, prob=.05, name="external causes", name2="of pump failure")
```

---

 applyCollapse

*Set a gate node for collapsed state on initial rendering.*


---

**Description**

Modifies an existing fault tree by setting the Collapse field of the selected node to 1.

**Usage**

```
applyCollapse(DF, on)
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
on	The ID of the basic element node to be defined uncertain.

**Value**

Returns the input fault tree dataframe amended with an entry defining collapsed initial state for the selected node.

**References**

- Rauzy, Antoine, et. al. (2013) Open PSA Model Exchange Format v2.0 open-psa.org
- Limnios, Nikolaos (2007) Fault Trees ISTE Ltd.
- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers
- Ericson II, Clifton A. (2011) Fault Tree Analysis Primer CreateSpace Inc.

**Examples**

```

mytree <-ftree.make(type="or")
mytree <- addLogic(mytree, at=1, type= "and", name="A and B failed")
mytree <- addProbability(mytree, at=2, prob=.01, name="switch A failure")
mytree <- addProbability(mytree, at=2, prob=.01, name="switch B failure")
mytree <- addLogic(mytree, at=1, type= "and", name="A and C failed")
mytree <- addDuplicate(mytree, at=5, dup_id=3)
mytree <- addProbability(mytree, at=5, prob=.01, name="switch C failure")
mytree <- applyCollapse(mytree, on=5)

```

cutsets

*Fault Tree Minimal Cut Set Determination***Description**

Determines minimal cutsets by various methods.

**Usage**

```
cutsets(DF, ft_node=1, method="mocus", by="tag")
```

**Arguments**

DF	A fault tree dataframe such as returned from <code>ftree.make</code> or related add... functions.
ft_node	A gate node ID treated as top of (sub)tree to be calculated.
method	The method for calculation either 'mocus' or 'prime-implicants'
by	Selection of identifier for each element of the cutset either 'tag' or 'id'

**Value**

Returns a list of matrices for each of cut set lengths found. Each element is defined by its unique ID assigned in the fault tree or by its unique Tag applied by the user.

**References**

Fussell, J., Vesely, W.E. (1972) A New Method for Obtaining Cut Sets for Fault Trees Transactions ANS, No. 15

Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.

Ericson, Clifton A. II (2005) Hazard Analysis Techniques for System Safety John Wiley & Sons

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center

O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons

Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission

Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA

Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

Rauzy, Antoine (1993) "New algorithms for fault trees analysis" Reliability Engineering System Safety, volume 40

Limnios, Nikolaos (2007) Fault Trees ISTE,Ltd.

Bedford, Tim, Cooke, Roger (2012) Probabilistic Risk Analysis Foundations and Methods Cambridge University Press

## Examples

```
minex2<-ftree.make(type="and")
minex2<-addProbability(minex2, at="top", prob=.01, tag="X1", name="X1")
minex2<-addLogic(minex2, at="top", type="or", tag="G1", name="G1")
minex2<-addProbability(minex2, at="G1", prob=.02, tag="X2", name="X2")
minex2<-addProbability(minex2, at="G1", prob=.03, tag="X3", name="X3")
minex2<-addLogic(minex2, at="top", type="or", tag="G2", name="G2")
minex2<-addDuplicate(minex2, at="G2", dup_of="X3")
minex2<-addProbability(minex2, at="G2", prob=.04, tag="X4", name="X4")
minex2_cs<-cutsets(minex2)
```

---

ftree.calc

*Fault Tree Calculation*

---

## Description

ftree.calc performs gate-by-gate calculations from bottom to top of fault tree.

## Usage

```
ftree.calc(DF, use.bdd=FALSE)
```

## Arguments

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
use.bdd	A logical determining whether to use the bdd for probability calculations rather than simple solutions.

## Value

Returns a dataframe containing 18 columns for holding data, results, and connection information.



## References

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers
- Rauzy, Antoine (1993) "New algorithms for fault trees analysis" Reliability Engineering System Safety, volume 40
- Limnios, Nikolaos (2007) Fault Trees ISTE,Ltd.
- Bedford, Tim, Cooke, Roger (2012) Probabilistic Risk Analysis Foundations and Methods Cambridge University Press

## Examples

```
minex2<-ftree.make(type="and")
minex2<-addProbability(minex2, at="top", prob=.01, tag="X1", name="X1")
minex2<-addLogic(minex2, at="top", type="or", tag="G1", name="G1")
minex2<-addProbability(minex2, at="G1", prob=.02, tag="X2", name="X2")
minex2<-addProbability(minex2, at="G1", prob=.03, tag="X3", name="X3")
minex2<-addLogic(minex2, at="top", type="or", tag="G2", name="G2")
minex2<-addDuplicate(minex2, at="G2", dup_of="X3")
minex2<-addProbability(minex2, at="G2", prob=.04, tag="X4", name="X4")
minex2<-ftree.calc(minex2, use.bdd=TRUE)
```

---

ftree.make

*Fault Tree Creation*

---

## Description

ftree.make prepares an initial, single row, dataframe, which will be built upon as the tree is developed.

## Usage

```
ftree.make(type, reversible_cond=FALSE, cond_first=TRUE, human_pbf=NULL,
  start_id=1, system_mission_time=NULL, label="", name="", name2="",
  description="")
```

**Arguments**

type	The logic type for the top gate. Possible gates are "or", "and", "inhibit", "priority", and "alarm". Gate types "vote" and "atleast" are disallowed in top event, place these under an OR gate.
reversible_cond	A boolean value used only by the conditional gate type indicating whether repair of the input condition is viable to the model.
cond_first	A boolean signifying whether the first child to an INHIBIT, ALARM, or PRIORITY logic gate should be taken as the condition. Alternatively, if FALSE, the second child will be taken as a condition. This is primarily a graphic display issue.
human_pbf	A probability of failure for a human to respond as needed to an alarm. This value is only used by the alarm gate.
start_id	An integer value for the starting unique ID, useful for transfer objects.
system_mission_time	An optional method for setting mission_time for the entire tree. It is also possible to set mission_time as a global variable. Use of system_mission_time in ftree.make will take precedence.
label	An identifying string for the logic gate. Use of label defines the convention for rest of tree construction.
name	An identifying string for the logic gate.
name2	A second line, if needed for the identifying string label
description	An optional string providing more detail for the resultant event.

**Value**

Returns a dataframe holding data, results, and connection information.

**References**

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <- ftree.make(type="and", name="a specific undesired event")
```

---

`ftree2bdd`*Generation of Binary Decision Diagram*

---

**Description**

Prepares a BDD string in if-then-else form '`<tag,if,else>`'

**Usage**

```
ftree2bdd(DF, ft_node=1)
```

**Arguments**

DF	A fault tree dataframe object.
ft_node	A gate node ID treated as top of (sub)tree to be calculated.

**References**

Rauzy, Antoine (1993) "New algorithms for fault trees analysis" Reliability Engineering System Safety, volume 40

Limnios, Nikolaos (2007) Fault Trees ISTE,Ltd.

---

`ftree2html`*Fault Tree Rendered in HTML*

---

**Description**

Prepares a web page from an ftree dataframe for a visualization of the data.

**Usage**

```
ftree2html(DF,dir="", write_file=TRUE)
```

**Arguments**

DF	A fault tree dataframe object.
dir	A character string for an absolute directory in which R can read and write.
write_file	A logical controlling whether to perform the write operation.

**Value**

Returns a character vector with escaped quote characters, suitable for writing to disk. Optionally, this vector will be written to a file taking the name of the object passed in as DF and appending '.html'.

## References

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons

## Examples

```
mytree <- ftree.make(type="or", name="site power loss")  
ftree2html(mytree, write_file=FALSE)
```

---

ftree2table	<i>Fault Tree Tabular Subview</i>
-------------	-----------------------------------

---

## Description

Delivers an informative subview from an ftree dataframe with condensed output.

## Usage

```
ftree2table(DF)
```

## Arguments

DF                    A fault tree dataframe object.

## Value

Returns a new condensed dataframe that is a subview of the ftree object.

## References

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons

## Examples

```
mytree <- ftree.make(type="or", name="site power loss")  
ftree2table(mytree)
```

---

hierarchyDF2json      *JSON formatting for tabular hierarchy data*

---

### Description

Converts data from a flat-table dataframe to a recursive json structure suitable for passing to D3 heirarchy objects.

### Usage

```
hierarchyDF2json(DF, id.col=1, parent.col=2, data.col=NULL,
  children.key="children", keys.tolower=TRUE, reverse_child_order=FALSE,
  dir="", write_file=FALSE )
```

### Arguments

DF	A dataframe object with unique identification column and a column containing parent node identifications. The first row must contain the root node of the hierarchy.
id.col	The name or number of the column holding unique identifiers, default is 1.
parent.col	The name or number of the column holding parent node identifications, default is 2. Entry in row one of this column will be ignored.
data.col	A vector of column numbers from the dataframe to be passed as json data, default is all columns.
children.key	A string to be used as the key for children entries.
keys.tolower	A logical indicating whether to convert column names of the input dataframe to lower case, when passing keys to the json format.
reverse_child_order	A logical indicating whether to reverse the order of child nodes under each parent. This is useful when desiring nodes to form from top to bottom in a horizontal tree structure.
dir	A character string for an absolute directory in which R can read and write.
write_file	A logical controlling whether to perform the write operation.

### Value

Returns a character vector with escaped quote characters, suitable for writing to disk. Optionally, this vector will be written to a file taking the name of the object passed in as DF and appending '.json'.

### References

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
 O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
 Ericson II, Clifton A. (2011) Fault Tree Analysis Primer CreateSpace Inc.

**Examples**

```
mytree <- ftree.make(type="or", name="conveyor belt fire")
hierarchyDF2json(mytree, id.col=1, parent.col=2, data.col=c(1,2))
```

---

parameter\_conversion    *Parameter Conversion Helper Functions*

---

**Description**

Access to a set of functions performing parameter conversions applicable to FaultTree scripting needs,

**Usage**

```
parameter_conversion(conv, param)
```

**Arguments**

conv	A string holding the name of a conversion function, or its assigned numerical equivalent.
param	A vector holding values appropriate for the requested conversion. See Details below.

**Details**

Conversion functions and their expected arguments are listed as follows:

```
conv param[1] param[2] param[3] 1 "prob2lam" prob 2 "prob2meanw" prob wshape time_shift 3
"wscale2mean" wscale wshape time_shift 4 "meanw2scale" wmean wshape time_shift 5 "sigma2ef"
sigma conf_limit 6 "ef2sigma" ErrFunc conf_limit 7 "meanln2mu" meanln sigma
```

**Value**

Returns a value according to the conversion requested.

**References**

- Fussell, J., Vesely, W.E. (1972) A New Method for Obtaining Cut Sets for Fault Trees Transactions ANS, No. 15
- Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.
- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mission_time=20
mttf<-1/parameter_conversion("prob2lam", .2)
```

pc

*Parameter Conversion Helper Functions***Description**

Access to a set of functions performing parameter conversions applicable to FaultTree scripting needs,

**Usage**

```
pc(conv, param)
```

**Arguments**

conv	A string holding the name of a conversion function, or its assigned numerical equivalent.
param	A vector holding values appropriate for the requested conversion. See Details below.

**Details**

Conversion functions and their expected arguments are listed as follows:

```
conv param[1] param[2] param[3] 1 "prob2lam" prob 2 "prob2meanw" prob wshape time_shift 3
"wscale2mean" wscale wshape time_shift 4 "meanw2scale" wmean wshape time_shift 5 "sigma2ef"
sigma conf_limit 6 "ef2sigma" ErrFunc conf_limit 7 "meanln2mu" meanln sigma
```

**Value**

Returns a value according to the conversion requested.

**References**

- Fussell, J., Vesely, W.E. (1972) A New Method for Obtaining Cut Sets for Fault Trees Transactions ANS, No. 15
- Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.
- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mission_time=20
mttf<-1/pc(1, .2)
```

---

prob2lam

*reverse calculation of exponential lambda from probability*

---

**Description**

A simplistic helper function for converting fixed probability to a fail rate using known exposure time.

**Usage**

```
prob2lam(prob)
```

**Arguments**

prob            A fixed probability value that is to be converted to fail rate for exposed element entry.

**Value**

Returns the lambda value that will produce the fixed probability with environment object mission\_time.

**References**

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons  
Ericson II, Clifton A. (2011) Fault Tree Analysis Primer CreateSpace Inc.

**Examples**

```
mission_time<-8760
mttf=1/prob2lam(.6)
```



---

probability

*Probability Calculation by BDD or mcub*


---

**Description**

Performs a calculation at a selected fault tree gate node.

**Usage**

```
probability(DF, ft_node=1, method="bdd")
```

**Arguments**

DF	A fault tree dataframe object.
ft_node	A gate node ID treated as top of (sub)tree to be calculated.
method	The method for calculation either 'bdd' or 'mcub'

**Details**

For BDD probability a binary decision diagram is generated on which a recursive algorithm is operated to generate the exact probability. For mcub (minimal cutset upper bound) the mocus algorithm is run to determine minimal cutsets. The upper bound estimate for probability is calculated by a probabilistic sum of the individual cutset probabilities.

**References**

Ericson, Clifton A. II (2011) Fault Tree Analysis Primer CreateSpace Inc.  
Ericson, Clifton A. II (2005) Hazard Analysis Techniques for System Safety John Wiley & Sons  
Rauzy, Antoine (1993) "New algorithms for fault trees analysis" Reliability Engineering System Safety, volume 40  
Limnios, Nikolaos (2007) Fault Trees ISTE,Ltd.  
Bedford, Tim, Cooke, Roger (2012) Probabilistic Risk Analysis Foundations and Methods Cambridge University Press

---

tagconnect

*Interpretation of Node ID by tag Name*


---

**Description**

Enables tree building improvement by allowing reference to nodes by tag.

**Usage**

```
tagconnect(DF, at, source=FALSE)
```

**Arguments**

DF	A fault tree dataframe such as returned from ftree.make or related add... functions.
at	An ID value or tag name for reference to a node.
source	A logical indicating whether to evaluate multiple occurrences of the tag to identify the source of duplication. Default of FALSE will cause the function to fail in case of multiple occurrence of tag provided as 'at'.

**Value**

Returns the ID value for the node whether it is a tag string or the actual ID value.

**References**

- Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center
- O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons
- Vesely, W.E., Goldberg, F.F., Roberts, N.H., Haasl, D.F. (1981) Fault Tree Handbook U.S. Nuclear Regulatory Commission
- Vesely, W.E., Stamatelato, M., Dugan, J., Fragola, J., Minarick, J., Railsback, J. (2002) Fault Tree Handbook with Aerospace Applications NASA
- Doelp, L.C., Lee, G.K., Linney, R.E., Ormsby R.W. (1984) Quantitative fault tree analysis: Gate-by-gate method Plant/Operations Progress Volume 3, Issue 4 American Institute of Chemical Engineers

**Examples**

```
mytree <-ftree.make(type="and", name="common cause failure", name2="of redundant pumps")
mytree<-addActive(mytree,at="top",mttf=3,mttr=12/8760, tag="p1", name="Pump")
mytree <- addProbability(mytree, at="top", prob=.05, name="common cause", name2="beta factor")
pumpIDvalue<-tagconnect(mytree, at="p1")
```

---

test.ftree

*Fault Tree Object Test*


---

**Description**

test.ftree compares dataframe column names with those of an ftree object.

**Usage**

```
test.ftree(DF)
```

**Arguments**

DF	A FaultTree dataframe object
----	------------------------------

**Value**

Returns True for object match, else False.

**References**

Nicholls, David [Editor] (2005) System Reliability Toolkit Reliability information Analysis Center  
O'Connor, Patrick D.T. (1991) Practical Reliability Engineering John Wiley & Sons

**Examples**

```
mytree <- ftree.make(type="or", name="site power loss")  
test.ftree(mytree)
```

# Index

## \* package

FaultTree-package, 2

addActive, 3

addDemand, 4

addDuplicate, 5

addExposed, 6

addHouse, 8

addLatent, 9

addLogic, 10

addProbability, 12

addUndeveloped, 13

applyCollapse, 14

cutsets, 15

FaultTree-package, 2

ftree.calc, 16

ftree.make, 17

ftree2bdd, 19

ftree2html, 19

ftree2table, 20

hierarchyDF2json, 21

parameter\_conversion, 22

pc, 23

prob2lam, 24

probability, 25

tagconnect, 25

test.ftree, 26