white queen

Safety Strategies

Report

CATS Software Manual

16 August 2008
WQ 080816-07

Annex to Final Report of:

Causal Model for Air Transport Safety (CATS)

Produced for Ministry of Transport and Water Management of the Netherlands

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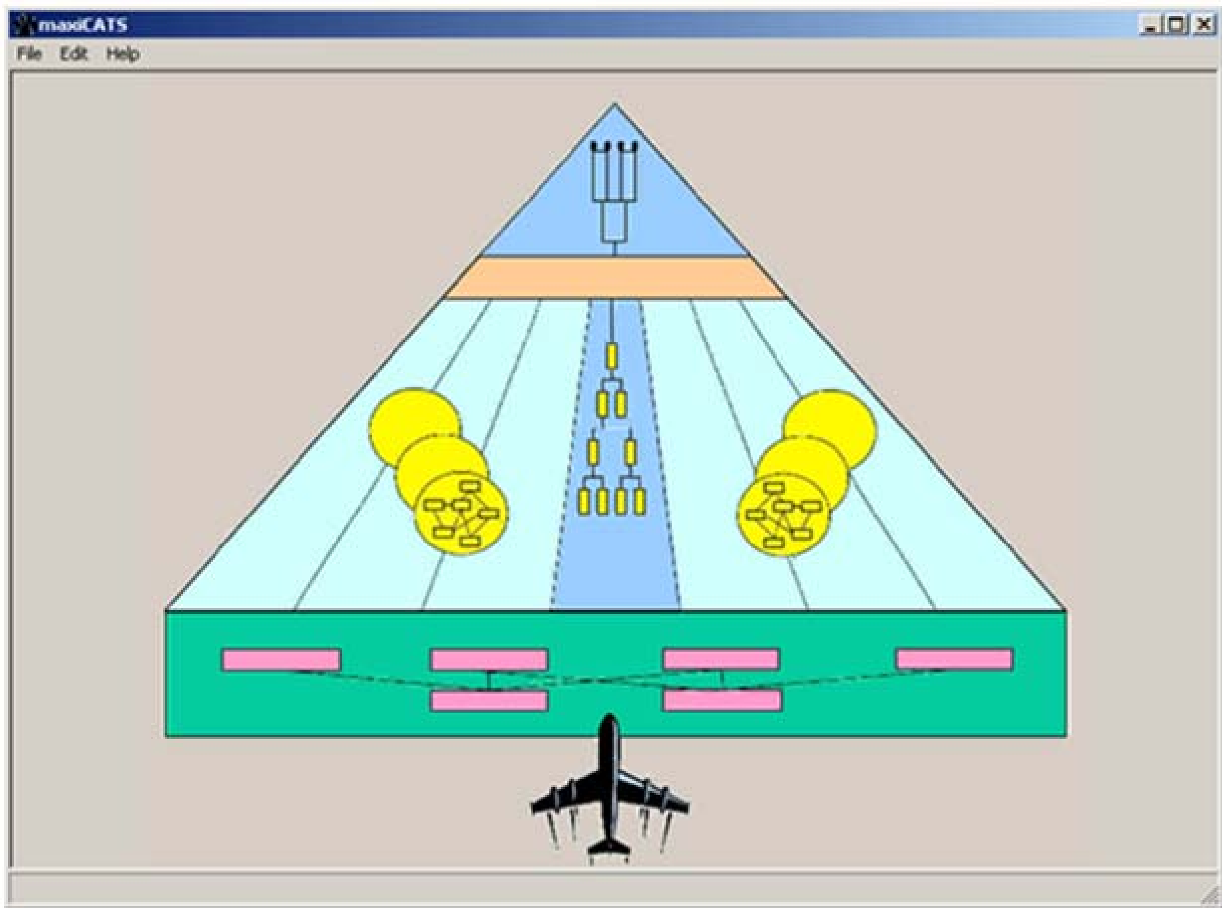
About

Help version: CATS1v4, 13 July 2008
Produced by: White Queen BV

Introduction to CATS



CATS is a program developed to calculate risk per year of the outcomes of a flight, a group of flights, or multiple flight groups for the **Causal Model forAir Transport Safety**

CATS can be used to calculate the risk associated with for example an airport or a company's flight operations, or a single flight.

Glossary

ACAS Airborne collision avoidance system
AL Approach and Landing
ATC Air traffic control
CFIT Controlled Flight Into Terrain
ER En route
GPWS Ground proximity warning system
LLWAS Low level windshear alert system
LOCT Loss of Control Take-off
LOCF Loss of Control Flight
LOCL Loss of Control Landing
MSAW Minimum safe altitude warning system
PWS Predictive wind-shear warning system
RIMCAS Runway incursion monitoring and conflict alert system
RTO Rejected Take Off
STCA Short term conflict alert system
TA Taxi
TAR Terrain avoidance radar
TO Take Off

CATS System requirements

Microsoft® Windows® XP with Service Pack 2 (or better)
1GHz processor or better
at least 1GB of RAM (2GB preferred)
100MB free disk to install
at least 2GB free disk to run

CATS is supplied as a setup.exe file. Double clicking on this file will open the installer. The setup file makes a directory Kingdom of the netherlands with subdirectory CATS. The following files are installed (these may change with different versions of CATS):

↓Name	Ext	Size	Date	Attr
[..]		<DIR>	09/01/2008 14:05	----
maxiCATSSetup58	exe	12,758,630	09/01/2008 14:05	-a--

c:\Program Files\Kingdom of the Netherlands\Cats*.*

↑Name	Ext	Size	Date	Attr
[..]		<DIR>	09/01/2008 14:32	----
[CodeSite]		<DIR>	09/01/2008 14:22	----
[Data]		<DIR>	09/01/2008 14:37	----
[Run]		<DIR>	09/01/2008 14:32	----
changes	txt	11,324	09/01/2008 04:00	-a--
maxiCATS	chm	436,852	17/09/2007 20:17	-a--
maxiCATS	exe	2,469,888	09/01/2008 03:52	-a--
maxiCATS	ini	917	09/01/2008 14:36	-a--
MTParserCOM	dll	344,064	08/10/2007 11:09	-a--
UnicornEngineComLib	dll	360,448	08/01/2008 14:50	-a--
UniNet	exe	5,629,738	08/01/2008 14:49	-a--
UniNet	ini	242	09/01/2008 14:37	-a--

c:\Program Files\Kingdom of the Netherlands\Cats\Data*.*

↑Name	Ext	Size	Date	Attr
[..]		<DIR>	09/01/2008 14:22	----
CATSpaws	mdb	2,748,416	08/01/2008 11:09	-a--
0VeryGBBN_08jan08	bbn	552,960	08/01/2008 15:13	-a--
0VeryGBBN_08jan08	rvinfo	44,543	08/01/2008 15:09	-a--
0VeryGBBN_08jan08	tps	10,520,000	08/01/2008 15:09	-a--
test58	CATS	31,462	09/01/2008 02:58	-a--

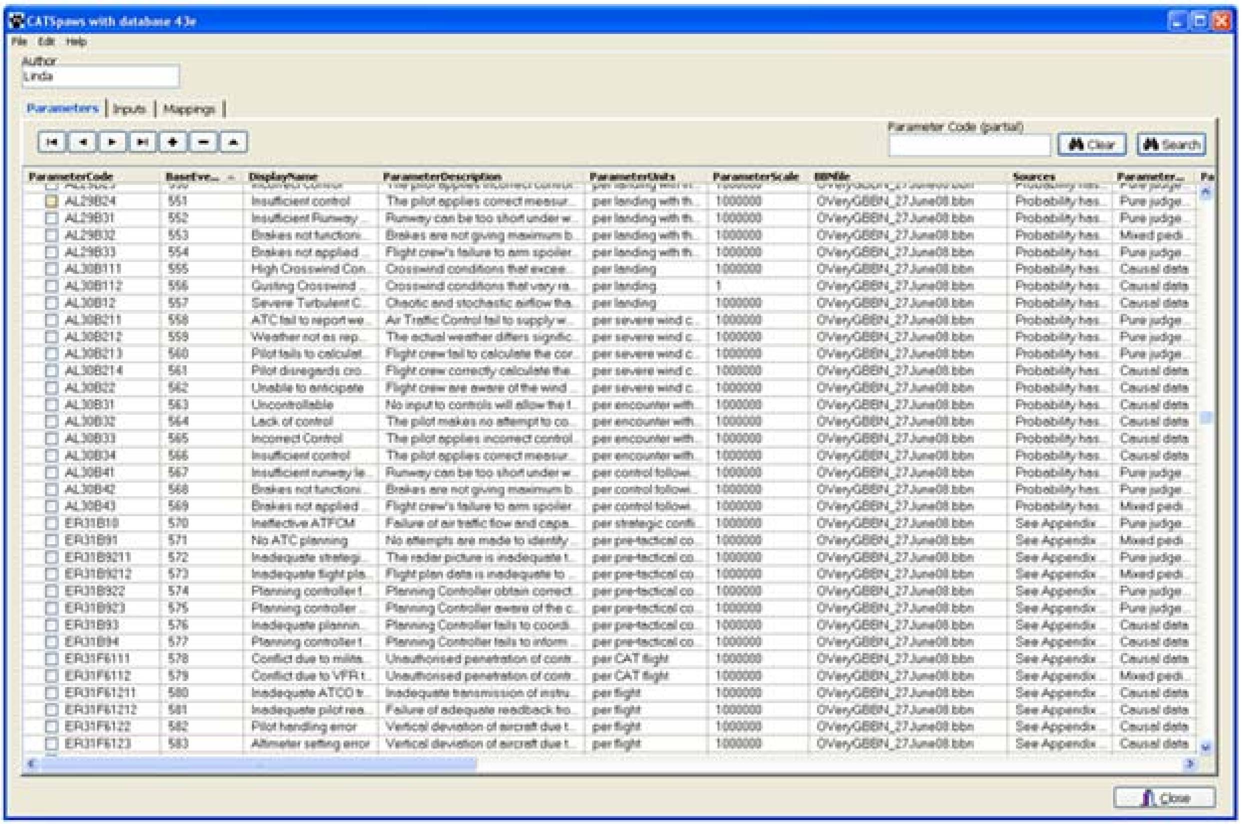
MaxiCATS is the exe which provides the communication and interface with the BBN software, Uninet.
maxiCATS.chm is the help file.
In the data directory
a) the BBN files, and
b)CATSPAWS which contains the decoder for the coded BBN, providing coded events with names and units and links to the sources of the data. (Will discuss this in separate presentation). The directory Run only appears once MaxiCATS is run.

Starting CATS

Open CATS by clicking on the exe file - maxiCATS

CATSpaws

This is a database file which links the BBN node names with the relevant display information in CATS. CATSPAWS takes all the nodes in the BBN and looks for something in CATSPAWS with that name. if it finds it it says what the BBN is in the BBN field. If not it adds the missing code but the other fields will be blank



ParameterCode	BaseEve...	DisplayName	ParameterDescription	ParameterUnits	ParameterScale	BBNfile	Sources	Parameter...
AL29B24	551	Insufficient control	The pilot applies correct measur...	per landing with th...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL29B31	552	Insufficient Runway ...	Runway can be too short under w...	per landing with th...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL29B32	553	Brakes not functioni...	Brakes are not giving maximum b...	per landing with th...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Mixed pedi...
AL29B33	554	Brakes not applied ...	Flight crew's failure to arm spoiler...	per landing with th...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B111	555	High Crosswind Con...	Crosswind conditions that excee...	per landing	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B112	556	Gusting Crosswind ...	Crosswind conditions that vary ra...	per landing	1	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B12	557	Severe Turbulent C...	Chaotic and stochastic airflow tha...	per landing	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B211	558	ATC fail to report we...	Air Traffic Control fail to supply w...	per severe wind c...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B212	559	Weather not as rep...	The actual weather differs signific...	per severe wind c...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B213	560	Pilot fails to calculat...	Flight crew fail to calculate the cor...	per severe wind c...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B214	561	Pilot disregards cro...	Flight crew correctly calculate the...	per severe wind c...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B22	562	Unable to anticipate	Flight crew are aware of the wind ...	per severe wind c...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B31	563	Uncontrollable	No input to controls will allow the t...	per encounter with...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B32	564	Lack of control	The pilot makes no attempt to co...	per encounter with...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B33	565	Incorrect Control	The pilot applies incorrect control...	per encounter with...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B34	566	Insufficient control	The pilot applies correct measur...	per encounter with...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Causal data
AL30B41	567	Insufficient runway le...	Runway can be too short under w...	per control followi...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B42	568	Brakes not functioni...	Brakes are not giving maximum b...	per control followi...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Pure judge...
AL30B43	569	Brakes not applied ...	Flight crew's failure to arm spoiler...	per control followi...	1000000	O'VeryGBBN_27June08.bbn	Probability has...	Mixed pedi...
ER31B10	570	Ineffective ATFCM	Failure of air traffic flow and capa...	per strategic confli...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Pure judge...
ER31B91	571	No ATC planning	No attempts are made to identify ...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Mixed pedi...
ER31B9211	572	Inadequate strategi...	The radar picture is inadequate t...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Pure judge...
ER31B9212	573	Inadequate flight pla...	Flight plan data is inadequate to ...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Mixed pedi...
ER31B922	574	Planning controller f...	Planning Controller obtain correct...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Pure judge...
ER31B923	575	Planning controller ...	Planning Controller aware of the c...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Pure judge...
ER31B93	576	Inadequate plannin...	Planning Controller fails to coordi...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31B94	577	Planning controller f...	Planning Controller fails to inform ...	per pre-tactical co...	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31F6111	578	Conflict due to milita...	Unauthorised penetration of contr...	per CAT flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31F6112	579	Conflict due to VFR t...	Unauthorised penetration of contr...	per CAT flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Mixed pedi...
ER31F61211	580	Inadequate ATCO tr...	Inadequate transmission of instru...	per flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31F61212	581	Inadequate pilot rea...	Failure of adequate readback fro...	per flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31F6122	582	Pilot handling error	Vertical deviation of aircraft due t...	per flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data
ER31F6123	583	Altimeter setting error	Vertical deviation of aircraft due t...	per flight	1000000	O'VeryGBBN_27June08.bbn	See Appendix ...	Causal data

From Rev 6 22 June 2008

Purpose

-To store all the data used in the CATS model in one place
-A bookkeeping process which ensures the source and pedigree of the data are traceable
-To have a centralized data store that always has the latest data in
-To have a link between CATSPAWS and the CATS software model so that it is easy to consistently update it and to automate the appearance of the output from the BBN (currently just a parameter codename.

Fields

The names here are documented exactly as they appear in the CATSPAWS edit program. The field names in the CATSPAWS database are given [in parenthesis]

Parameter Code [ParameterCode]

This is the unique code that links a node in the BBN (Bayesian Belief Net) with all the displayed data in MaxiCATS.
Short text (must conform to variable naming - see below)
e.g. AL26B24
ParameterCodename must be usable in an equation, so must conform to rules which are:

First character must be alphabetic (ie a to z), remaining characters can be alphanumeric or underbar. Case is notsignificant, ie to01b11 is the same as TO01B11, and any mixture of capitalisation. (so no-one should use case as a distinguishing feature of anything)
We may need a limit on the length for uninet, something like 15 characters (What are BBN/uninet program constraints?)
Rules:
LEGEND
AA = Phase (TA, TO, ER, AL) etc any other phase codings required...MUST be AlphabetAlphabet and unique)
Can also be AAAA and AAAAAA for multiple phases

NN=2 digit Numbers (01, 02, 03 etc)
a=one letter
n=a number with one or more digits(1,2,3,..11,12..or...1,11,111,12,121....)
nn=end event numbers (beginning 00 for not the initator, then 01, 02..etc.)
_ = underbar

CODES
1) Boxes in the ESD backbone part that are NOT end events:

AANNan_

Reason: Now that upper and lower case cannot be distinguished it causes boxes to have same code as in the FT in a few rare cases so we add _

2) Boxes in the ESD backbone part that are end events

AANNan_nn

Reason is that _nn is how we recognise ESD end nodes in MaxiCATS for sorting purposes

3) Boxes in the fault tree

AANNan

Reason: We need the phase (AA) and ESD number(NN).
In the fault trees the author can use scenario type code (L, E,F, etc. in place of AA as long as it is clear somewhere as to which phase the quantification numbers refer) - see ParameterCodenameDotlist

Additional parameter codes for flight crew, ATCO and Maintenance performance models

1)Start letter:
z (lower case)
This will ensure all the nodes for the Flight crew model, ATC (and Maintenance eventually) all appear together in the BBN parameters list and not all over the place when alphabetically sorted. This will when sorted Z-A produce these model BBNs first then TO then ER then AL, which makes sense and which will make QA and testing much much easier

2) Model idenitifier
Code for the model. The underbar after each model code (for Flight crew, Air traffic control, Maintenance) separates the model i.d. from the next part of the code
FC_
ATC_
MNT_

3) Flight phase
The usual TO, ER, AL but also TOERAL for nodes where the 3 phases have been combined. This also lines up the sorted sequence nicely

4) Descriptive Part/Person
Here the rule is the nature of the parameter followed by person referred to (if relevant)
eg.
TrainCap
TrainFO
ExpATCO
ExpCap
ExpFO
UnSuitCrew
UnSuitCap
UnSuitFO
Coord
Traffic
AirGen
Workload

Complete codes:
zFC_TOWorkload
zFC_TOWeather
zFC_TOUnSuitFO
zFC_TOUnSuitCrew
zFC_TOUnSuitCap
zFC_TOFatigue
zFC_TOERALTrainFO
zFC_TOERALTrainCap
zFC_TOERALLangDif
zFC_TOERALExpFO
zFC_TOERALExpCap
zFC_TOERALAirGen
zFC_ERWorkload
zFC_ERWeather
zFC_ERUnSuitFO
zFC_ERUnSuitCrew
zFC_ERUnSuitCap
zFC_ERFatigue
zFC_ALWorkload
zFC_ALWeather
zFC_ALUnSuitFO
zFC_ALUnSuitCrew
zFC_ALUnSuitCap
zFC_ALFatigue
zATC_TOVisProc
zATC_TOTraffic
zATC_TOInterface
zATC_TOExpATCO
zATC_TOCoord
zATC_ERVisProc

zATC_ERTraffic
zATC_ERInterface
zATC_ERExpATCO
zATC_ERCoord
zATC_ALVisProc
zATC_ALTraffic
zATC_ALInterface
zATC_ALExpATCO
zATC_ALCoord

Additional parameter codes for Output nodes
OUT_PhaseName
e.g. OUT_Accident; OUT_TOVeerOff
Codes are:
OUT_TOERALAccident
OUT_TOALRunway_overrun
OUT_TOALRunway_veer_off
OUT_TOERALCollision_with_ground
OUT_ERIn_flight_break_up
OUT_ERALAircraft_lands_off_runway
OUT_ALAircraft_continues_landing_roll_damaged
OUT_TOALAircraft_damaged
OUT_ERCollision_in_mid_air
OUT_TOALCollision_on_runway
OUT_ERPersonal_injury
OUT_TOTake_off
OUT_ERLoss_of_control_in_flight
OUT_ERFire_in_flight
OUT_EREngine_failure_in_flight
OUT_ALCFIT
OUT_ALLanding
OUT_TOERALCollision
OUT_ERStructural_accident

2.**Parameter Codename Dotlist [ParameterCodenameDotlist]**
The Parameter Code name in the original DNV dot form from the FTs. These dotlisted names have all but disappeared in v.5_1 of the FTs.
Base event ID [BaseEventID]
A whole number
The base event number as given by DNV in the fault tree event listings

Display Name [DisplayName]
short text

This is the name of the parameter that the user will see in CATS
e.g. Flight crew maintain control
End nodes
In the case of an end node, the display name begins END followed by a space
Parameter Units [ParameterUnits]:
Short text
e.g. per inappropriate handling
ParameterDescription:

Long text.
This is the definition/long description of the parameter

Value [ParameterValue]

Number if continuous.
Text (comma separated values) if discrete
NB a text value could be a number as with Aircraft Generation
The value is currently typed into the BBN from the Fault trees in MS Excel
The value is seen on the inputs screen, the engine and on the results screens in MaxiCATS but currently all the values and SDs and min and max are all read from the BBN into maxiCATS and not from CATSPAWS. The values in CATSPAWS come from the Fault Trees. The values from the FTs are hand-typed into the BBN. This is because the FTs have been provided in MS Excel form as opposed to a database - this could be remedied in the future. One day CATSPAWS might become the definitive place for the BBN values and the BBN could look it up from CATSPAWS

8 Scale [ParameterScale]

Number
If blank it is taken as 1
Other values may be any number (1000000, for example)

Used to scale up or down the parameter depending on whether going to the BBN or coming from the BBN in relation to the value in MaxiCATS

Parameter Min [ParameterMin]

Number
Lower end of the distribution

Parameter Max [ParameterMax]

Number
Upper end of the distribution

Confidence Lower Limit [ConfidenceLowerLimit]

Number
Complete variability of the population of flights
5% lower limit confidence interval

Confidence Upper Limit [ConfidenceUpperLimit]

Number
95% upper limit confidence interval

Aircraft Continues [AircraftContinues]

Boolean True/False
If False it means it is an end node of an ESD which in the ESD backbone does not continue flight e.g. stops on runway, veer off, collision etc. Not necessarily an accident. E.g. continues landing roll ends the flight.

Charm [ParameterCharm]

Lookup which will display the appropriate colour in MaxiCATS based on the colours in the ESD backbone storybuild.
At the moment MaxiCATS only uses the red-yellow-green system to highlight the Codes in the display

Description	Colour
ESD black	Black
ESD green	Green
ESD grey	Grey
ESD red	Red

ESD turquoise Turquoise
ESD yellow Yellow

Pedigree [ParameterPedigree]

Lookup
Probability data - directly from event and exposure data (coloured green in the FT)
Causal data - based on the distribution of causes in the event data (coloured blue in the FT)
Mixed pedigree - deduced from other parameters (coloured white in the FT)
Group judgement - expert judgement using a structured elicitation process
Pure judgement - analyst judgement in the absence of any data (coloured yellow in the FT)
Unclassified - pedigree not yet recorded

Description	Colour
Probability data	Green
Causal data	Blue
Mixed pedigree	White
Group judgement	
Pure judgement	Yellow
Unclassified	

Date of Last Change [DateOfLastChange]

Short text
Entered automatically

Authors of changes (most recent first) [AuthorOfLastChange]

short text

Quality Assurance [QualityAssurance]

Long text
Free text field for notes made on quality checks, correction of the data, flagging of things needing to be fixed

Sources [Sources]

Long text

Regulation [Regulation]

Long text
Temporary placeholder. Free text field for mapping of the regulations onto the BBN. This is likely to become a completely separate table since there will be a one to many and a many to one mapping between the regulations and events in the model.

BBN file [BBNfile]

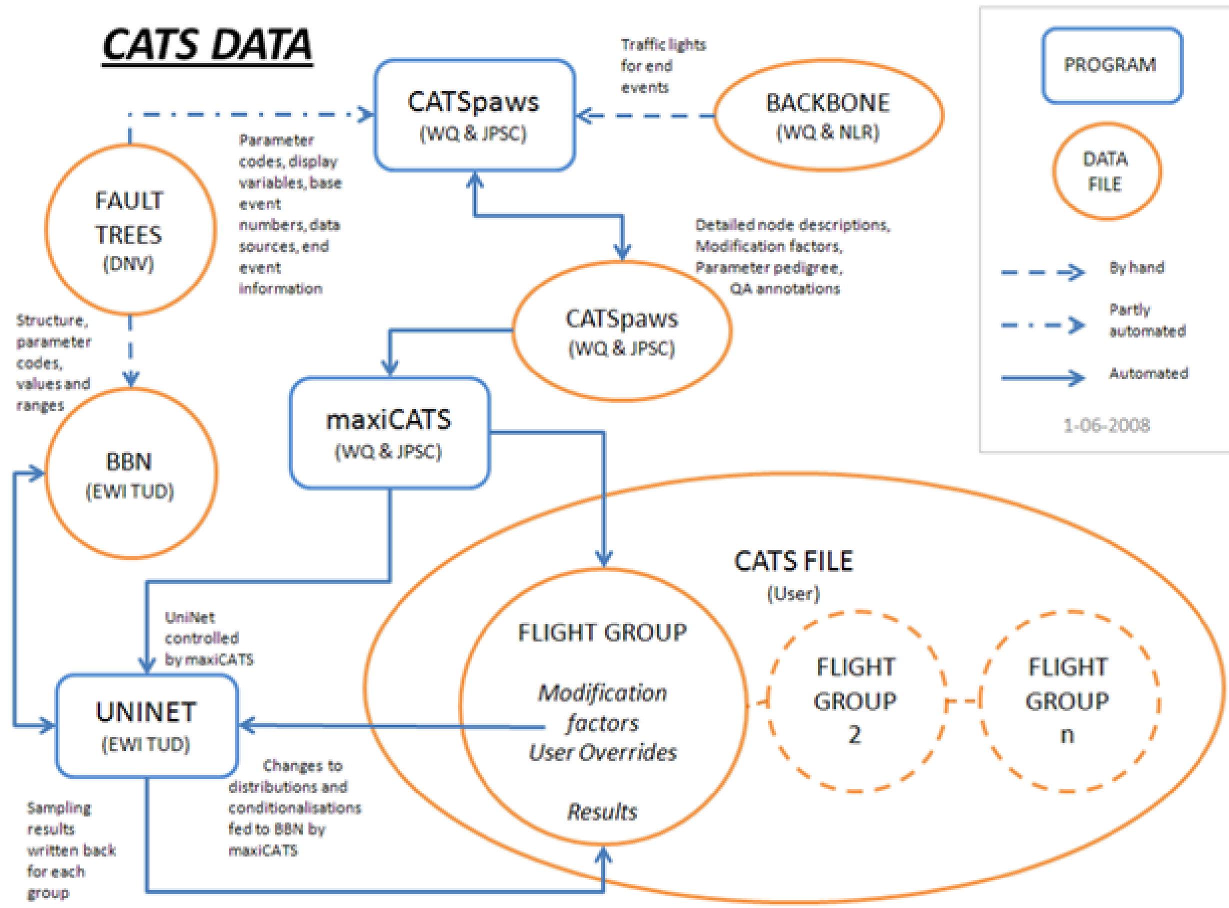
Ultimately the aim is to make an automated cross check and the relevant BBN file from the last check will be recorded. Currently it is not possible to see what is and what is not in the BBN from looking at CATSPAWS

NOTES:
Short text is max 255 characters,

Long text is effectively unlimited length and may contain line breaks.

Numbers should be constrained to use decimal point (.) And no thousands separator so that we can have comma separated lists.

Data Flow



CAT walk through the steps

STEPS

An overview of the key steps is given below. For further information consult the help on each step

Step 1: Flights. This sets up the names of user defined groups of flights. A number of flights per year can be assigned to each created flight group.

The purpose is that each group can be calculated separately with changes in parameters defined.Then the results of calculating with user defined flight group parameters can be compared with the baseline in Step 5.

Step 2 Inputs. When the group is not the baseline the user will want to specify inputs for a group of flights. Inputs will map onto the BBN nodes and modify them appropriately for each flight group.

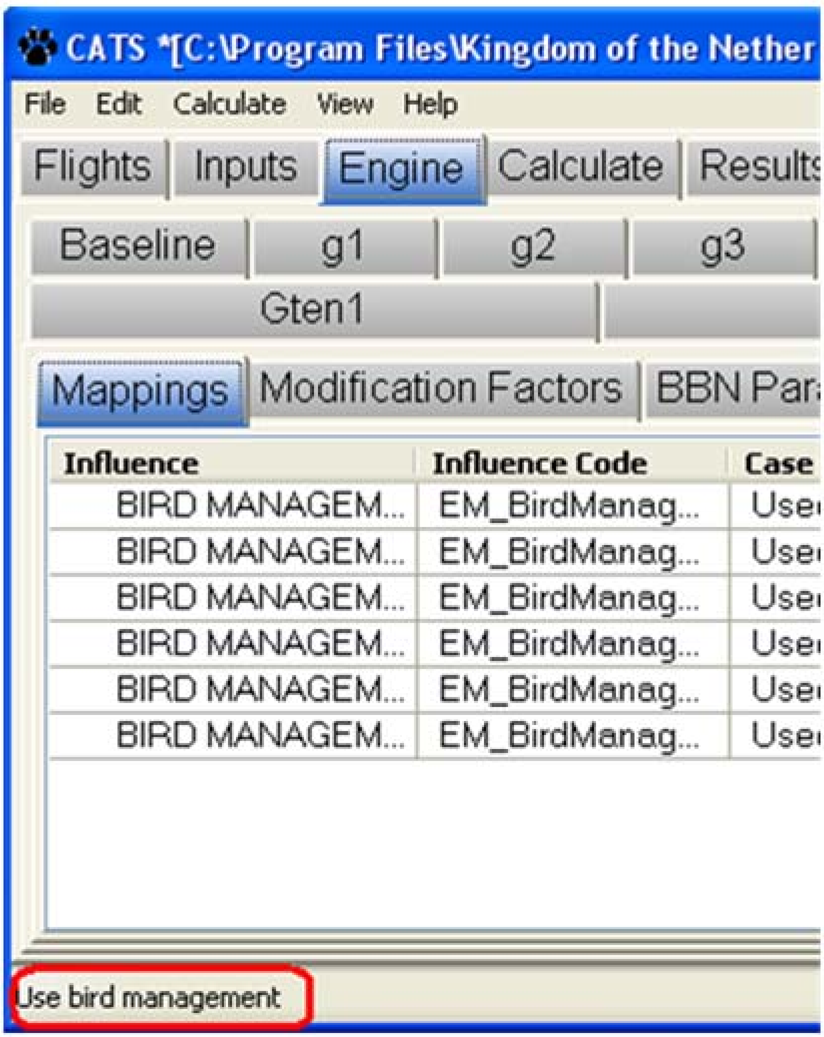
Step 3 Engine. User is currently allowed to override input data directly in the engine. The full set of BBN nodes can be examined.

Step 4 Calculate. This will calculate the results in the BBN based on the node parameters. The user will select number of samples and see a log of the calculation process.
Step 5 Results. The results show the probability per flight of the different events and the total frequency of final outcomes per year. Information on fatalities and costs are also provided .

Tips and tricks

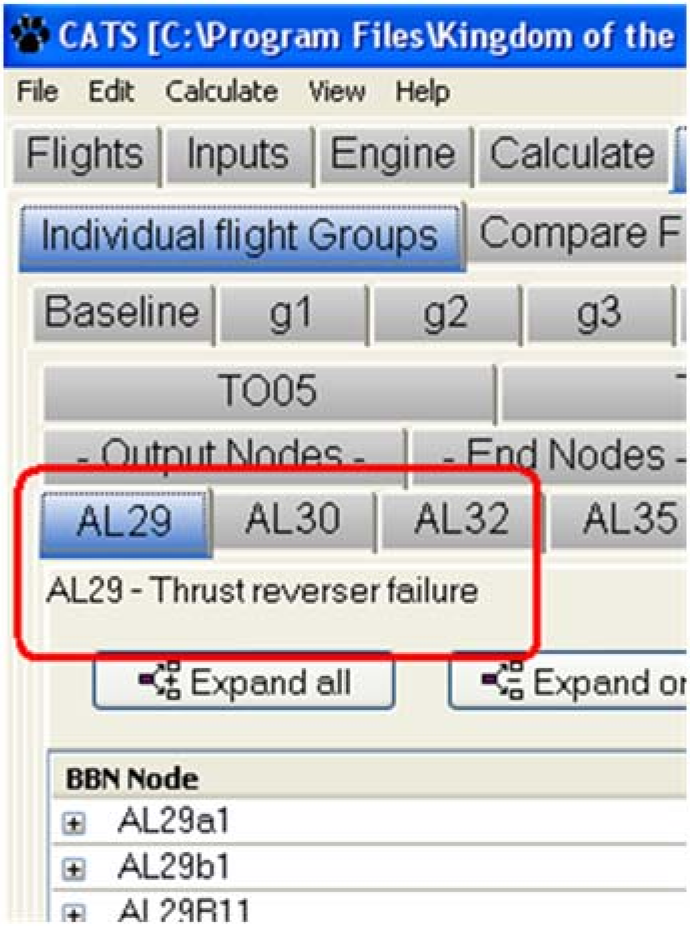
What is currently selected?

A selected tab always shows as blue. Be aware of this when looking at information and performing operations on a flight group.
When holding the cursor in the workspace the name of the flight group shows in the bar at the bottom.
When holding the cursor over any tab a hint appears of the name of the current flight group.



Which ESD?

On results tab this is displayed when the tab is selected



If the name of the ESD is not available by these means look at List of ESDs.

Useful Operations

On ceratin tabs useful operations can be performed which include

Alphabetical/Numerical sorting.

This is done by clicking on a column heading. Clicking once will cause A-Z or numeric Small->Large sorting depending on the data type, and clicking again will cause Z-A, Large->Small sorting.

Column sequences

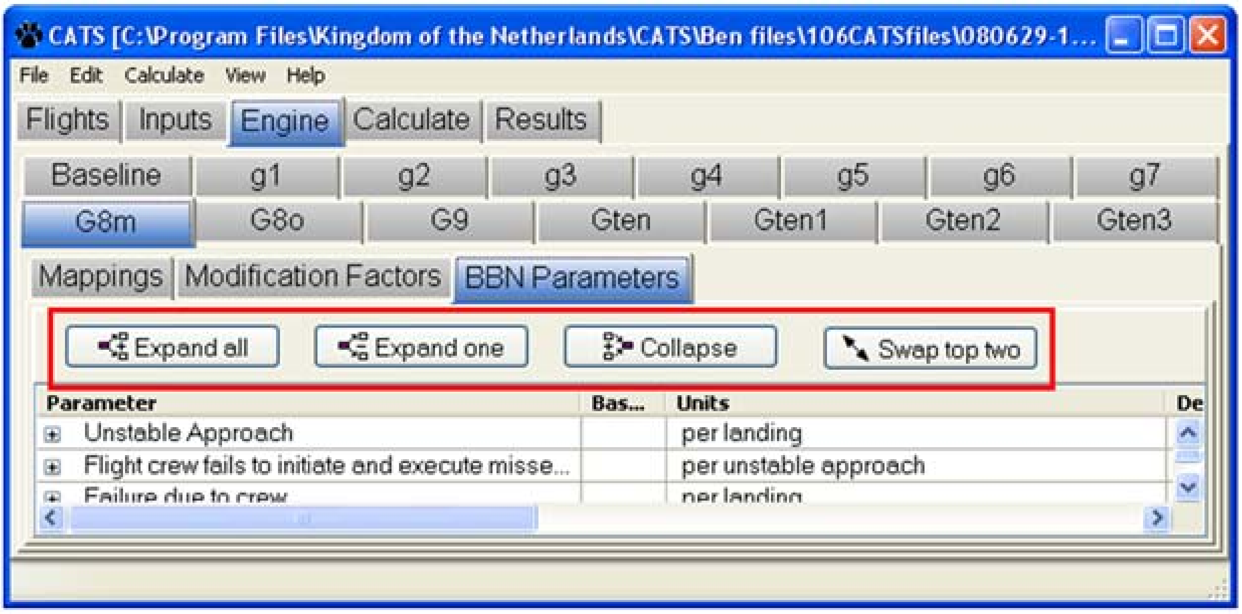
Click on the top of the column and drag- This will change the column position to the dropped position. This will be preserved until a new position is chosen.

Data displays

There are also buttons for the data displays:

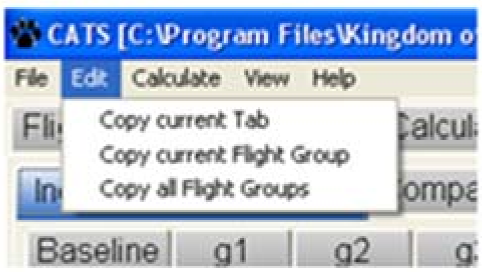
Expand all - Opens the node information to show all the data from CATSPAWS

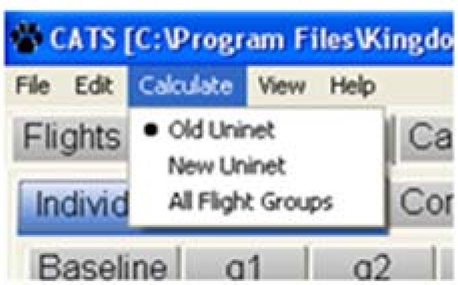
Expand one - Shows the node code if the display name is being shown or the display name if the parameter code is being shown
Collapse - Collapses the node back to one line of description
Swop top two - swops node information between display name and parameter code



Menus


CATS [C:\Program Fil
File
Edit
Calculate
View
New
Open...
Close
Save
Save As...
Revert
Print Setup...
Exit


CATS [C:\Program Files\Kingdom o
File
Edit
Calculate
View
Help
Copy current Tab
Copy current Flight Group
Copy all Flight Groups
Baseline
g1
g2


CATS [C:\Program Files\Kingdo
File
Edit
Calculate
View
Help
Flights
Old Uninet
New Uninet
All Flight Groups
Baseline
g1
g2


ogram Files\Kingdom
te
View
Help
Uninet
Unigraph
Unisens
g1
g2

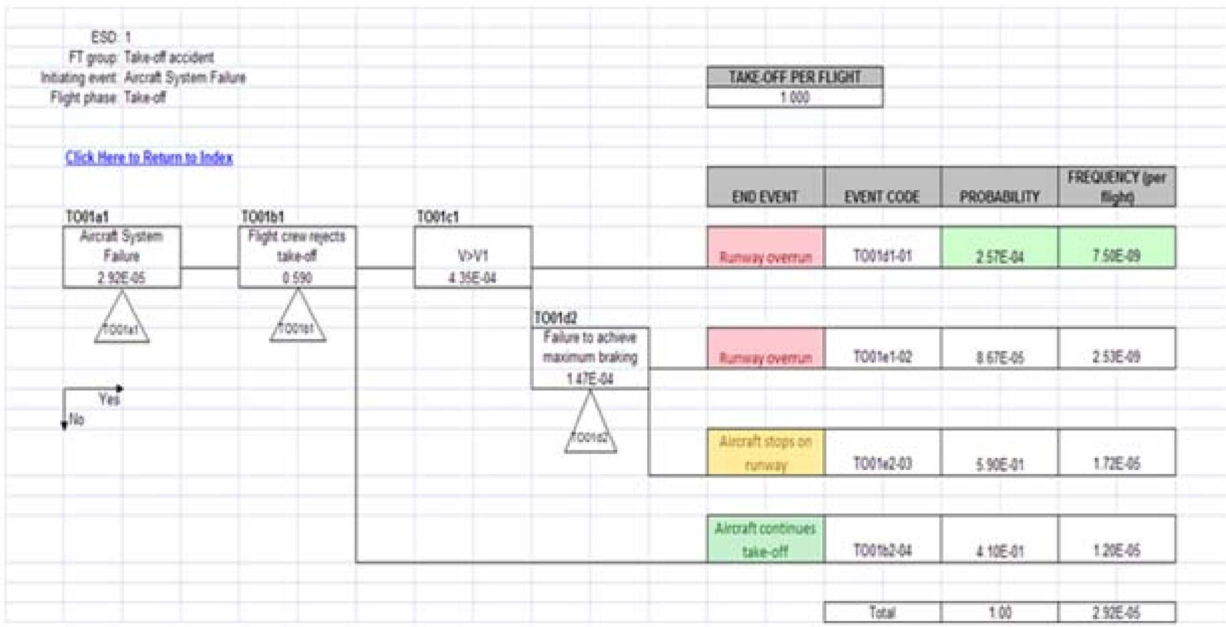
List of ESDs

ESDs are identified by their initiating events

ESD	Initiating event	Fault Tree group
1	Aircraft system failure	LOCT
2	ATC event	LOCT
3	Aircraft handling by flight crew inappropriate	LOCT
4	Aircraft directional control related systems failure	LOCT
5	Operation of aircraft systems by flight crew inappropriate	LOCT
6	Aircraft takes off with contaminated wing	LOCT
7	Aircraft weight and balance outside limits	LOCT
8	Aircraft encounters performance decreasing windshear after rotation	LOCT
9	Single engine failure	LOCT
10	Pitch control problem	LOCT
11	Fire on board aircraft	Fire/exp
12	Flight crew member spatially disorientated	LOCF
13	Flight control system failure	LOCF
14	Flight crew incapacitation	LOCF
15	Anti-ice system not operating	LOCF
16	Flight instrument failure	LOCF
17	Aircraft encounters adverse weather	Structural
18	Single engine failure	Engine
19	Unstable approach	LOCL
21	Aircraft weight and balance outside limits	LOCL
23	Aircraft encounters windshear during approach/landing	LOCL
25	Aircraft handling by flight crew during flare inappropriate	LOCL
26	Aircraft handling by flight crew during roll inappropriate	LOCL
27	Aircraft direction control related systems failure	LOCL
28	Single engine failure	LOCL
29	Thrust reverser failure	LOCL
30	Aircraft encounters unexpected wind	LOCL
31	Aircraft are positioned on collision course	Collision
32	Incorrect presence of aircraft/vehicle on runway in use	Collision
33	Cracks in aircraft pressure cabin	Structural
35	Flight crew decision error/operation of equipment error	CFIT
36	Ground collision imminent	Collision
37	Wake vortex encounter	LOCF

Some examples to illustrate the structures behind the events in the model: (Until these have been developed in full in the help files the user should open the original DNV fault trees Excel file and the NLR document- NLR-CR-2006-520- when working with CATS if they want to follow the details)

TO01 Aircraft System Failure



<u>Aircraft system failure</u>
The initiating event 'aircraft system failure' includes all system failures that could lead to an aborted take-off, with the exception of engine failures and system failures that can result in directional control problems. Engine failures and directional control system failures are addressed in ESD 9 and ESD 4 respectively. Pitch control problems during the take-off roll are addressed in ESD10.

<u>Flight crew rejects take-off</u>
A rejected take-off is defined as "failure to complete a take-off manoeuvre after take-off power has been applied". If, during the take-off run, a situation arises that potentially compromises a safe take-off and climb, the flight crew may elect to reject the take off. The decision whether or not to reject the take-off depends on the speed of the aircraft and the amount of runway remaining. At a certain point, the amount of runway available may not be sufficient to bring the aircraft to a complete stop. For this reason a *decision speed* V1 is calculated before each takeoff. The decision speed V1 is the maximum speed at which the take-off can be safely aborted and the aircraft can be brought to a complete stop at the remaining runway. At a speed below V1 the take-off can be safely rejected, at speeds above V1 the take-off should be continued. Typical V1 values for large commercial jet aircraft vary from 125 to 160 knots. The actual V1 depends on aircraft type, aircraft weight, wind, air density, temperature, and runway gradient. Some operators and aircraft manufactures have defined a speed up to which a take-off should be rejected for *all observed* failures. At speeds between this speed and the take-off decision speed V1, the take-off should be rejected *only in case of an engine failure and conditions affecting the safe handling of the aircraft*. Different policies exist among the operators regarding these takeoff

rejection criteria. The speed up to which a take-off should be rejected for all observed failures varies between 70-100 knots with a typical value in the order of 80 knots.

V > V1

The event V > V1 describes a situation where the rejected take-off is initiated at a speed higher than the decision speed V1. The decision speed V1 is the maximum speed at which the take-off can be safely aborted and the aircraft can be brought to a complete stop at the remaining runway. At a speed below V1 the take-off can be safely rejected, at speeds above V1 the take-off should be continued. Typical V1 values for large commercial jet aircraft vary from 125 to 160 knots. The actual V1 depends on aircraft type, aircraft weight, wind, air density, temperature, and runway gradient.

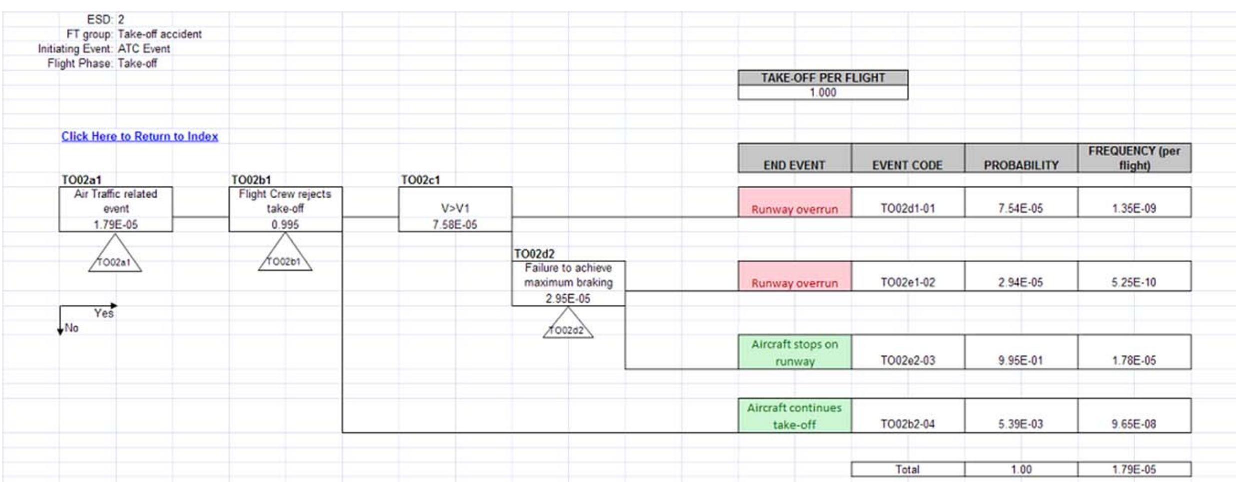
Failure to achieve maximum braking

Immediately following the decision to reject a take-off, the flight crew must start reducing the speed of the aircraft. Particularly in the case of a high speed rejected take-off, braking must start immediately using maximum braking power and all available deceleration devices: the liftdumpers (if available) are raised (manually or automatically), the brakes are applied (manually or automatically), and reverse thrust or propeller reverse is selected (if available). These actions must be conducted without delay and according to the standard operating procedures (SOP). Braking performance is strongly influenced by the runway conditions, if the runway is wet or flooded, or if it is covered with snow, slush or ice, tyre-to-ground friction is significantly reduced resulting in longer stopping distances.

TO02 ATC Event

NLR 2006 Quantification of ESDs.pdf

Go to Page 27



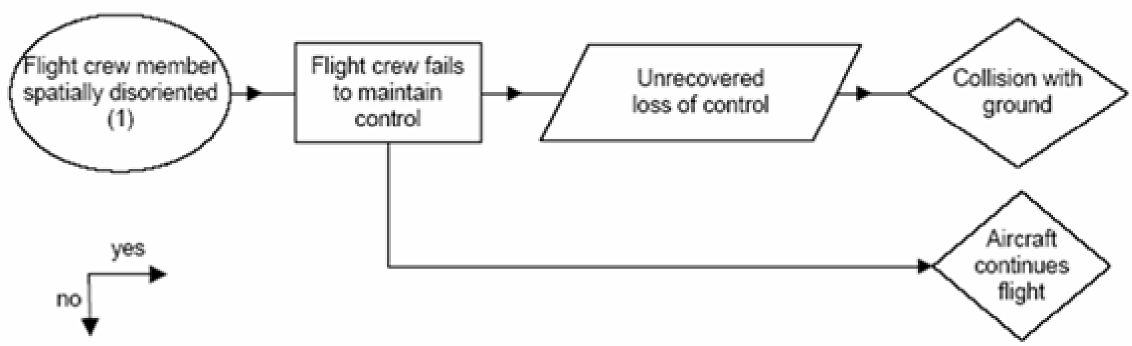
ATC event

For the purpose of this ESD, an ATC event is defined as any ATC related occurrence which could result in a decision to reject a take-off, with the exception of runway incursions. Possible separation infringements with other traffic on the departure runway (runway incursions) are excluded from this ATC event and are treated separately in ESD 32. Examples of 'ATC events' are possible separation infringements with another departure or with a missed approach on another runway. The problem situation could be caused by the aircraft in take-off (it did not have a take-off clearance yet) or by ATC (a take-off clearance is given while other traffic nearby). ATC can give an instruction to abort the take-off or the crew can independently decide
to perform a rejected take-off (RTO). An instruction by ATC to abort the take-off because of the presence of birds in the vicinity of the runway is also included in this initiating event.

ER12 Flight crew member spatially disorientated

ESD12 NLR (from NLR-CR-2006-520)

Accident type: uncontrolled collision with ground.
Flight phase: initial climb, en route, approach and landing.
Initiating Event: flight crew member spatially disoriented.



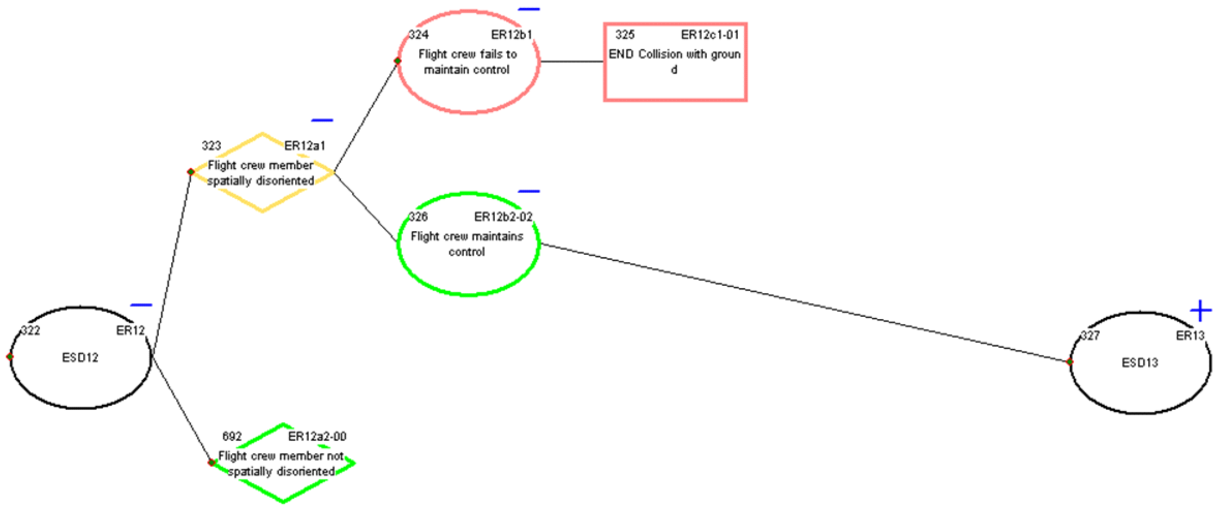
(1) Factors such as recognition of spatial disorentiation, hand over of control to other crew member come under this event.

Spatial orientation refers to a person's ability to perceive motion, position and attitude in relation to the surrounding environment. This capability depends upon the reception, integration and interpretation of sensory inputs from visual, vestibular, muscular and skin receptors. [Antuñano & Mohler, 1992]. Spatial disorientation occurs when a pilot has inadequate visual information or fails to attend to or properly interpret available information regarding the airplane's pitch and bank. Instead, a disoriented pilot relies on cues that are often misleading. The most hazardous illusions that lead to spatial disorientation result from ambiguous information received from motion sensing organs located in each inner ear. The sensory organs of the inner ear detect angular accelerations in the pitch, yaw, and roll axes and gravity and linear accelerations. During flight, the inner ear organs may be stimulated by

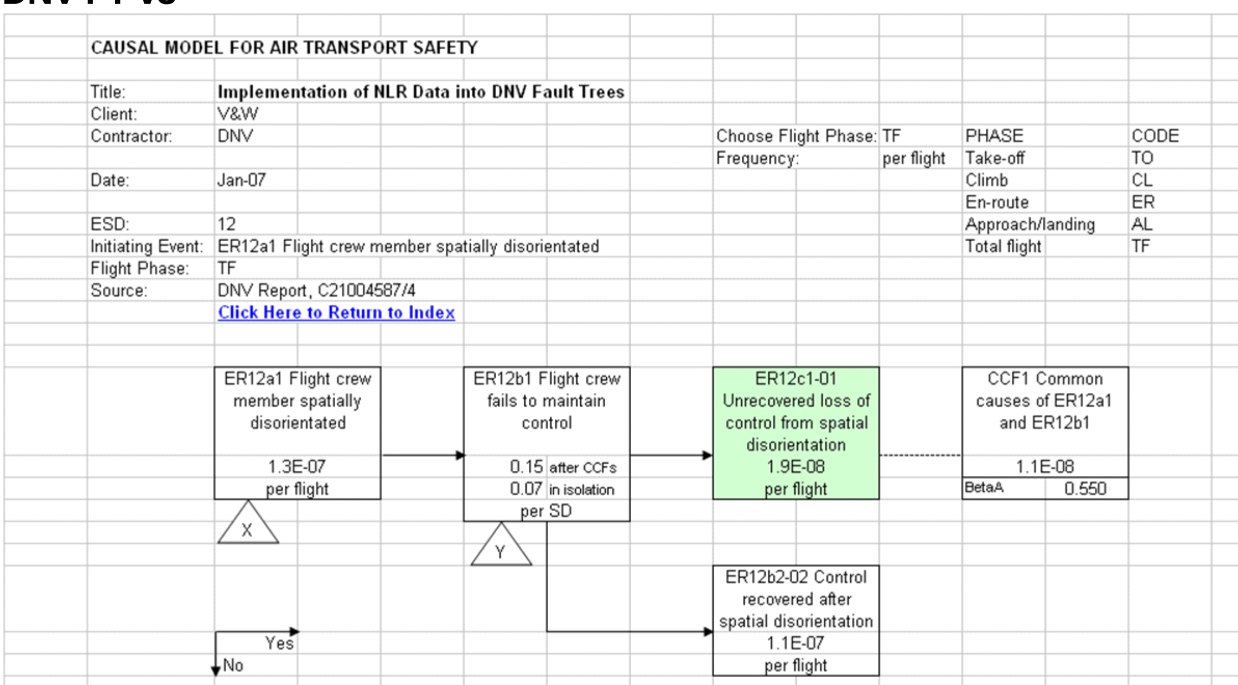
motion of the aircraft alone or along with head and body movement [NTSB, 2003].
Quantification of ESD 12 is based on the assumption that spatial disorientation refers to disorientation with respect to the attitude (pitch, roll and yaw) of the aircraft only. Disorientation with respect to aircraft's position and altitude are excluded. ESD 12 describes a loss of control accident as a result of spatial disorientation. In this type of accident the pilot's perception of aircraft attitude relative to the surface of the earth and the gravitational vertical plays a role, not his perception of position with respect to the surface of the earth. Situational awareness regarding the aircraft position and altitude are relevant in the context of a potential collision with terrain and are covered in ESD 35. Events where the flight crew lost situational awareness and landed on a wrong runway, taxied along the wrong route, lined-up the wrong runway etc., are covered by ESD 32.
It is often difficult to prove with certainty that spatial disorientation affected the pilot. However, in many accidents, weather conditions in combination with the aircraft trajectory (e.g. 'graveyard spin') are strong indications that the flight crew was spatially disoriented. In the ESD the initiating event, pivotal events and end states are defined as follows. Flight crew member spatially disoriented The Initiating Event is defined as the situation that a flight crew member suffers spatial disorientation, i.e. has inadequate visual information or fails to attend to or properly interpret available information regarding the airplane's pitch, roll or yaw angle or rate of rotation.

<u>Flight crew fails to maintain control</u>
This pivotal event refers to the ability of the flight crew to maintain control of the aircraft. This pivotal event does not necessarily imply a failure or error by the flight crew. The ability of the flight crew to maintain control of the aircraft is affected by human factors (fatigue, training etc), aircraft system failures, weather conditions etc. In this ESD the failure of the flight crew to maintain control refers to a situation where a flight crew spatial disorientation event occurs. It is then pivotal in the sequence of events whether any member of the flight crew detects the disorientation and gives over or takes-over control in time to maintain control of the aircraft.
<u>Collision with ground</u>
This end state refers to a possible outcome of a flight crew spatial disorientation event and includes any sort of collision with terrain (ground, water) or obstacles that results in injuries or fatalities or substantial damage to the aircraft.
<u>Aircraft continues flight</u>
This end state refers to the possible outcome of a flight crew spatial disorientation event when the flight crew continues the flight to the destination airport or diverts the aircraft to another airport. This includes occurrences where the non-affected pilot takes over control and occurrences where the pilot(s) succeed(s) in overcoming the disorientation.

Storybuild backbone



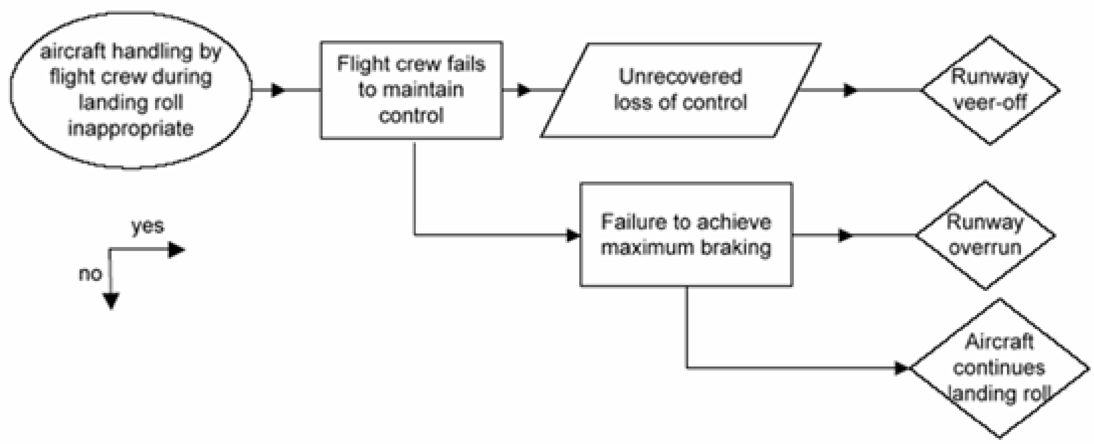
DNV FT v3



AL26 Aircraft handling by flight crew during landing roll inappropriate

ESD26 NLR (from NLR-CR-2006-520)

Accident type: uncontrolled collision with ground.
Flight phase: landing.
Initiating Event: aircraft handling by flight crew during landing roll inappropriate.



<u>Aircraft handling by flight crew during landing roll inappropriate</u>
This ESD describes the scenario in which a touchdown is made with a correct speed and sink rate, but due to an action by the crew during the landing roll, control of the aircraft is (temporarily) lost or maximum braking is not achieved. Included in this initiating event are offcentreline touchdowns. Inappropriate aircraft handling includes inappropriate use of rudder and aileron, inappropriate use of the steering tiller, delayed operation of deceleration devices such as lift dumpers, thrust reverser and wheel brakes and inappropriate differential braking. The occurrence of aquaplaning is also considered to be in the scope of this initiating event.
Flight crew fails to maintain control
This pivotal event refers to the ability of the flight crew to maintain (directional) control on the runway after touchdown.
<u>Failure to achieve maximum braking</u>
Immediately following touchdown, the flight crew must start reducing the speed of the aircraft. On most large aircraft, a 'positive' touchdown is required to make sure the aircraft switches to ground logic, which will automatically deploy lift dumpers (if available and armed) and will ensure a proper functioning of the autobrake system. Braking must start immediately using maximum braking power and all available deceleration devices: the lift-dumpers (if available) are raised (manually or automatically), the brakes are applied (manually or automatically), and reverse

thrust or propeller reverse is selected (if available). These actions must be conducted without delay and according to the standard operating procedures (SOP). Braking performance is strongly influenced by the runway conditions, if the runway is wet or flooded, or if it is covered with snow, slush or ice, tyre-to-ground friction is significantly reduced resulting in longer stopping distances.

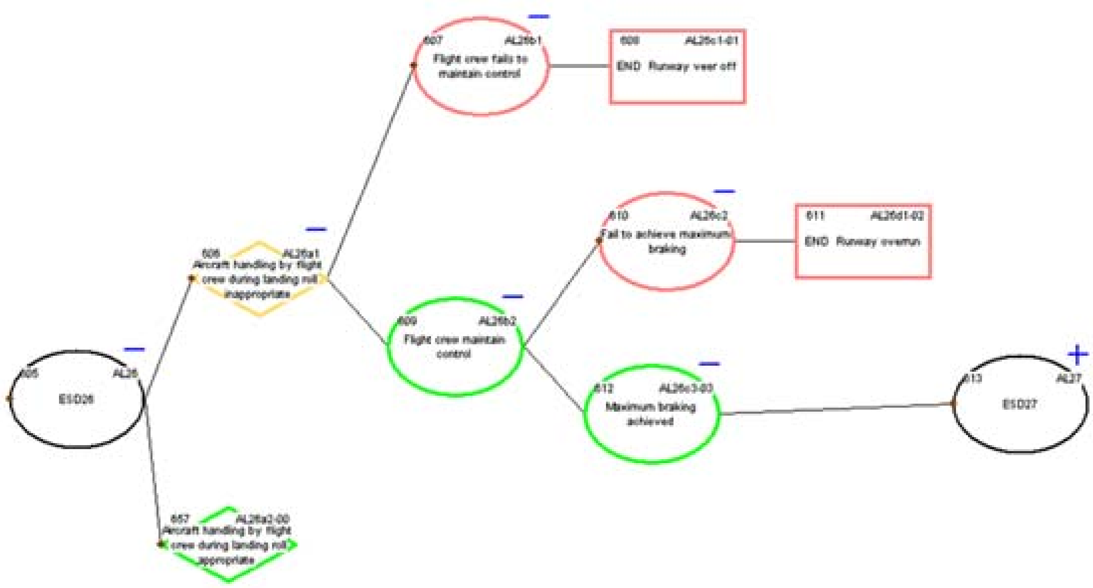
Runway overrun

A runway overrun is a situation where the aircraft is not able to come to a full stop before reaching the end of the runway. Occurrences where the aircraft cannot be brought to a halt before reaching the end of the runway but where flight crew deliberately steer the aircraft off the side of the runway in order to prevent a collision with obstacles located in line with the runway are also considered to be 'runway overruns'. The degree of damage is determined by the speed at which the aircraft leaves the runway and the possible presence of obstacles such as ditches, fences, approach lights, buildings, etc.

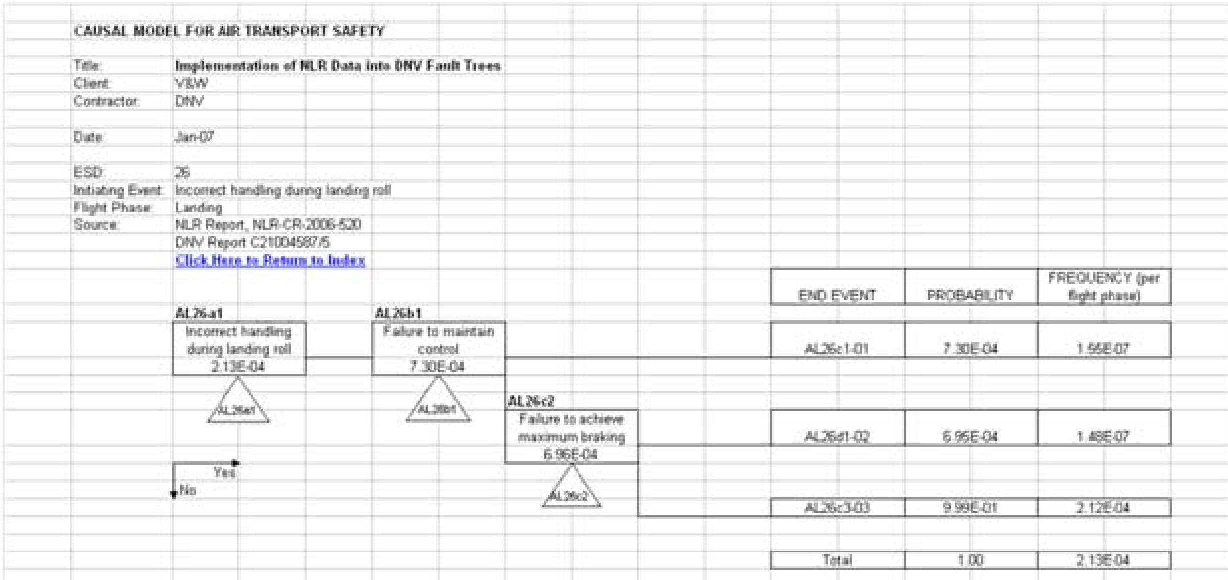
Runway veer-off

A runway veer-off is a situation where the flight crew is not able to maintain directional control and the aircraft deviates to the side of the runway and veers off it. Occurrences where the aircraft cannot be brought to a halt before reaching the end of the runway but where flight crew deliberately steer the aircraft off the side of the runway in order to prevent a collision with obstacles located in line with the runway are considered to be 'runway overruns'. The degree of damage is determined by the speed at which the aircraft leaves the runway, the veer-off angle, and the possible presence of obstacles such as ditches, fences, approach lights, buildings, etc.

AL26 Storybuild



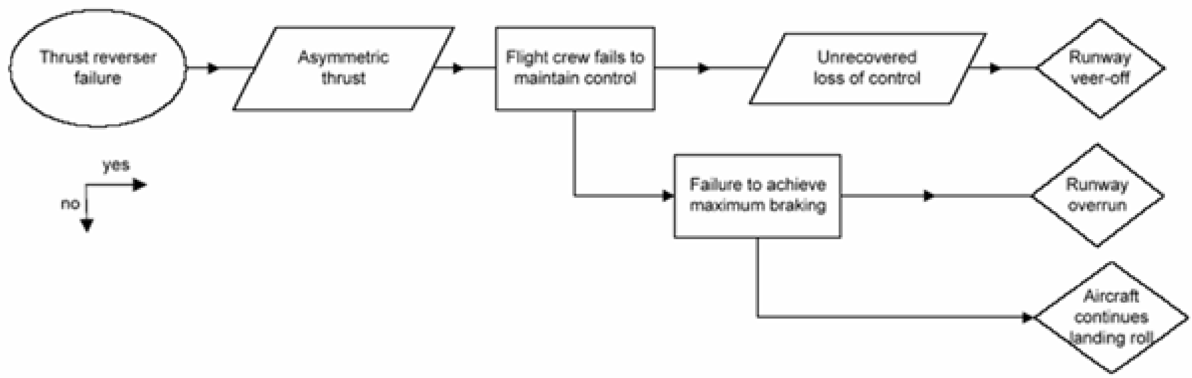
DNV FTv3


CAUSAL MODEL FOR AIR TRANSPORT SAFETY
Title: Implementation of NLR Data into DNV Fault Trees
Client: V&W
Contractor: DNV
Date: Jan-07
ESD: 26
Initiating Event: Incorrect handling during landing roll
Flight Phase: Landing
Source: NLR Report, NLR-CR-2006-520
DNV Report C21004587/5
Click Here to Return to Index
AL26a1
Incorrect handling during landing roll
2.13E-04
AL26a1
AL26b1
Failure to maintain control
7.30E-04
AL26b1
AL26c2
Failure to achieve maximum braking
6.96E-04
AL26c2
Yes
No
END EVENT
PROBABILITY
FREQUENCY (per flight phase)
AL26c1-01
7.30E-04
1.55E-07
AL26d1-02
6.95E-04
1.48E-07
AL26c3-03
9.99E-01
2.12E-04
Total
1.00
2.13E-04

AL29 Thrust reverser failure

ESD29 NLR (from NLR-CR-2006-520)

Accident type: uncontrolled collision with ground.
Flight phase: landing.
Initiating Event: thrust reverser failure.



A thrust reverser is a system that redirects a jet engine's airflow such that the resulting thrust force acts against the forward travel of the aircraft. On propeller driven aircraft reverse thrust is obtained by changing the pitch of the propeller blades to a negative angle, thereby directing air flow into the direction of travel. For the purpose of this ESD a thrust reverser failure is defined as a failure of system ATA 7830 reverser for aircraft with jet propulsion and a failure of system ATA 6120 propeller control for aircraft with propeller propulsion. Only technical malfunctions of the thrust reverser system are considered in this initiating event. Failures of the flight crew to correctly operate the thrust reverser system are covered in ESD 26.

Flight crew fails to maintain control

This pivotal event refers to the ability of the flight crew to maintain control of the aircraft. This pivotal event does not necessarily imply a failure or error by the flight crew. The ability of the flight crew to maintain control is affected by human factors (fatigue, training, etc), aircraft system failures, weather conditions, etc.

Failure to achieve maximum braking

Immediately following touchdown, the flight crew must start reducing the speed of the aircraft. On most large aircraft, a 'positive' touchdown is required to make sure the aircraft switches to ground logic, which will automatically deploy lift dumpers (if available and armed) and will ensure a proper functioning of the autobrake system. Braking must start immediately using maximum braking power and all available deceleration devices: the lift-dumpers (if available) are raised (manually or automatically), the brakes are applied (manually or automatically), and reverse thrust or propeller reverse is selected (if available). These actions must be conducted without delay and according to the standard operating procedures (SOP). Braking performance is strongly influenced by the runway conditions, if the runway is wet or flooded, or if it is covered with snow, slush or ice, tyre-to-ground friction is significantly reduced resulting in longer stopping distances.

Runway overrun

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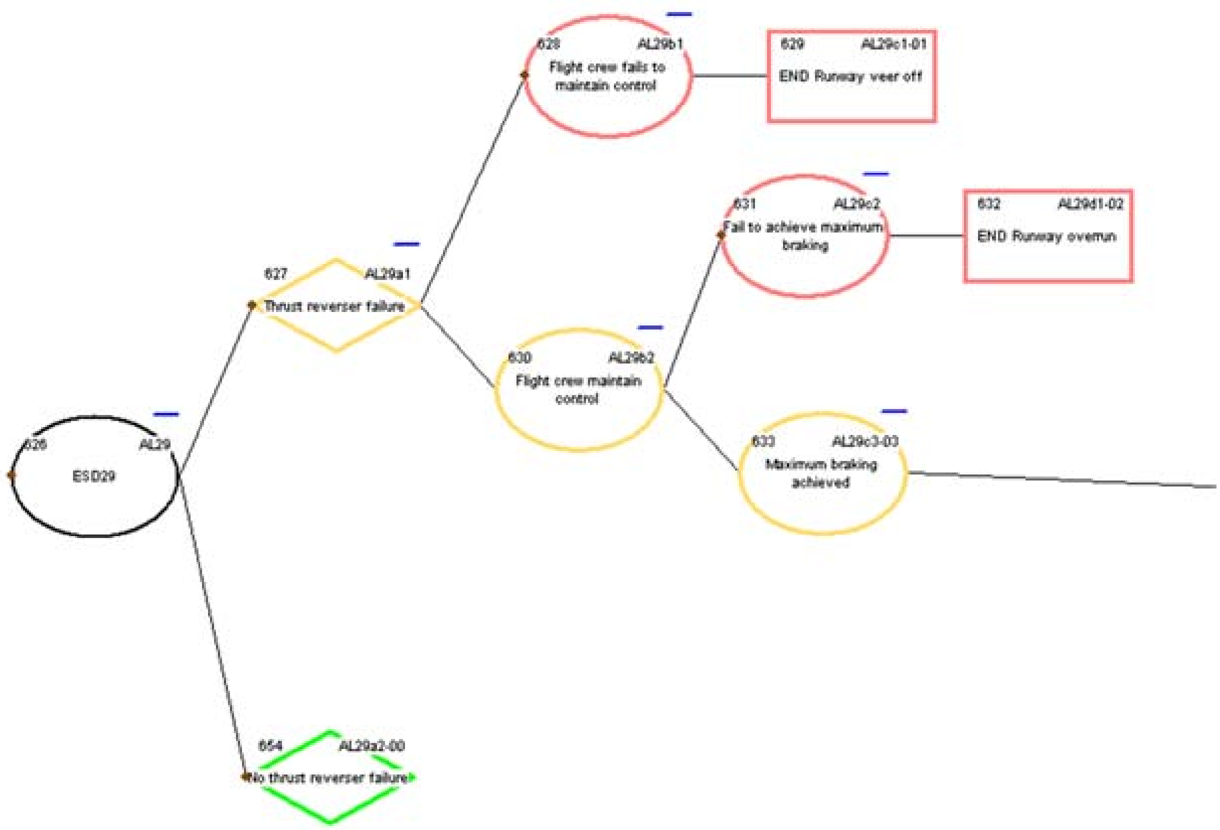
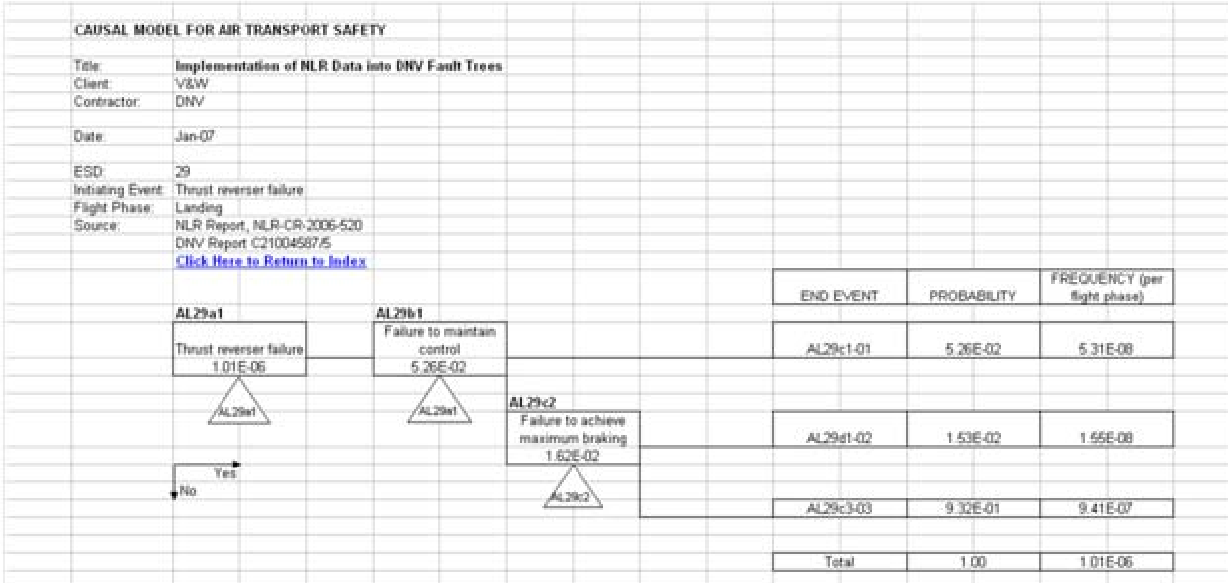
Runway veer-off

A runway veer-off is a situation where the flight crew is not able to maintain directional control and the aircraft deviates to the side of the runway and veers off it. Occurrences where the aircraft cannot be brought to a halt before reaching the end of the runway but where flight crew deliberately steer the aircraft off the side of the runway in order to prevent a collision with obstacles located in line with the runway are considered to be 'runway overruns'. The degree of damage is determined by the speed at which the aircraft leaves the runway, the veer-off angle, and the possible presence of obstacles such as ditches, fences, approach lights, buildings, etc.

Storybuild backbone WQ



DNV FTv.3

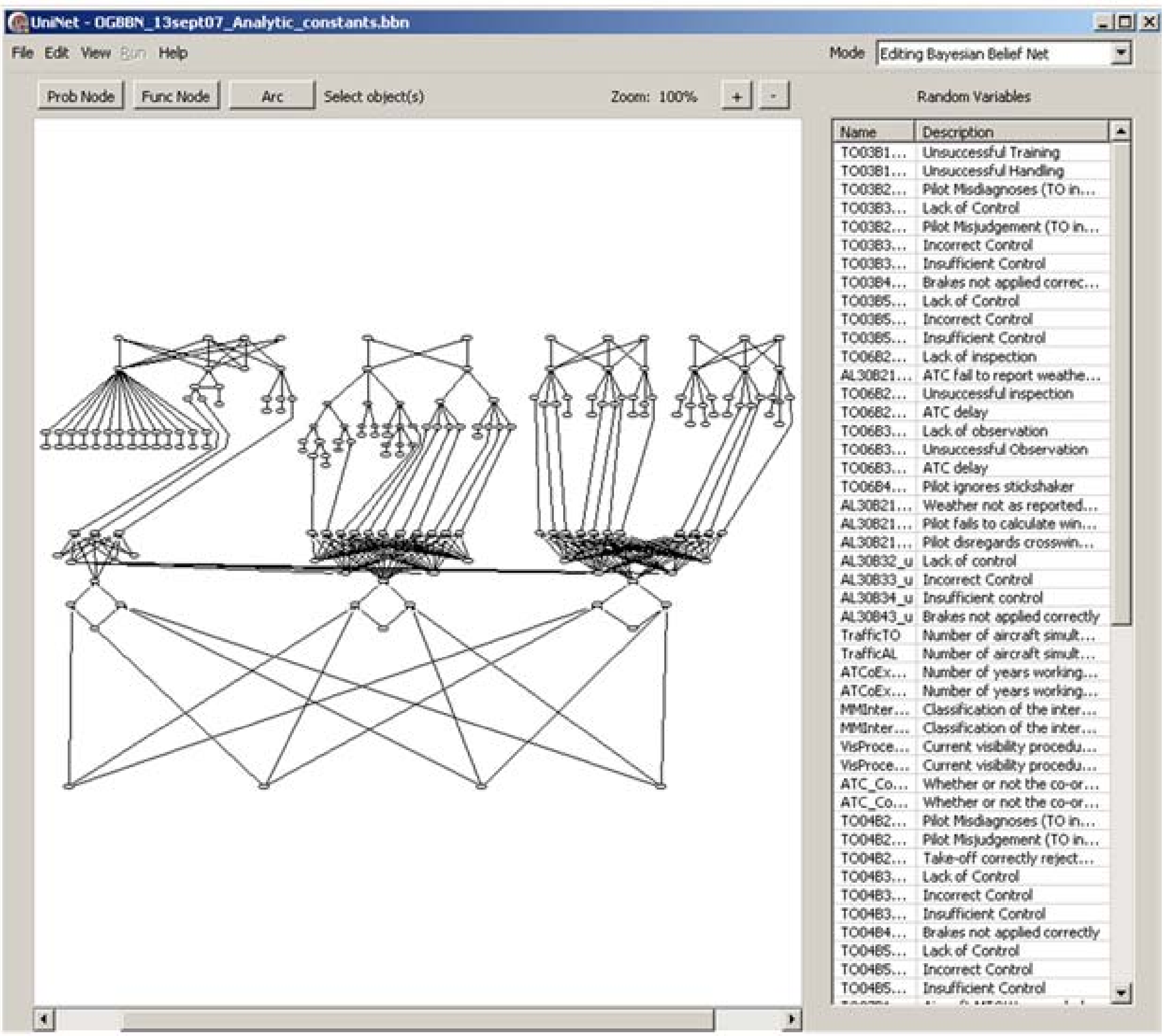

CAUSAL MODEL FOR AIR TRANSPORT SAFETY
Title: Implementation of NLR Data into DNV Fault Trees
Client: V&W
Contractor: DNV
Date: Jan-07
ESD: 29
Initiating Event: Thrust reverser failure
Flight Phase: Landing
Source: NLR Report, NLR-CR-2006-520
DNV Report C21004587/5
Click Here to Return to Index
AL29a1
Thrust reverser failure
1.01E-06
AL29b1
Failure to maintain control
5.26E-02
AL29c2
Failure to achieve maximum braking
1.62E-02
Yes
No
END EVENT
PROBABILITY
FREQUENCY (per flight phase)
AL29c1-01
5.26E-02
5.31E-08
AL29d1-02
1.53E-02
1.55E-08
AL29c3-03
9.32E-01
9.41E-07
Total
1.00
1.01E-06

Bayesian Belief Net BBN

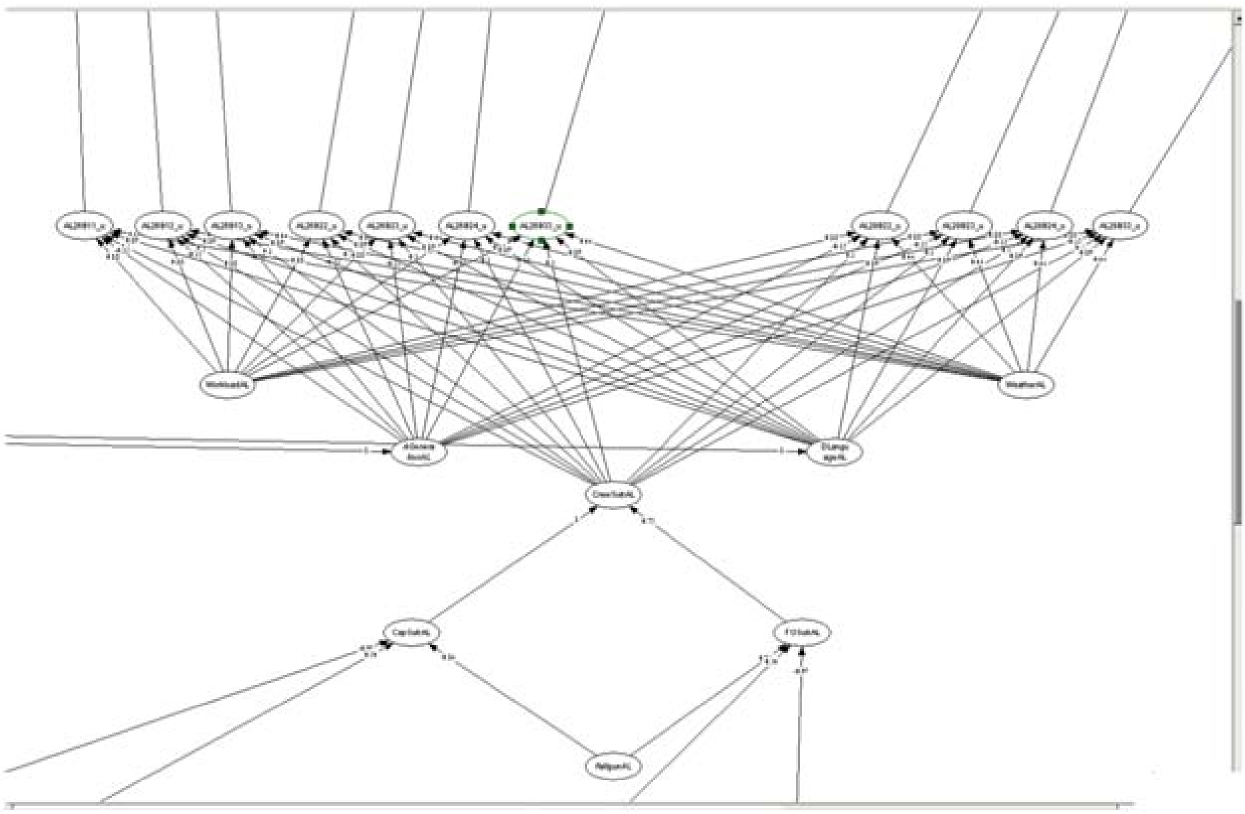
CATS displays the values of flight parameters generated by a Bayesian Belief Net in the program Uninet using the database CATSPAWS.

These BBN parameters can be changed:
a) By modifying predefined input variables
b) Directly by the user (user override)

The inputs are linked to nodes in the BBN (see figures below)

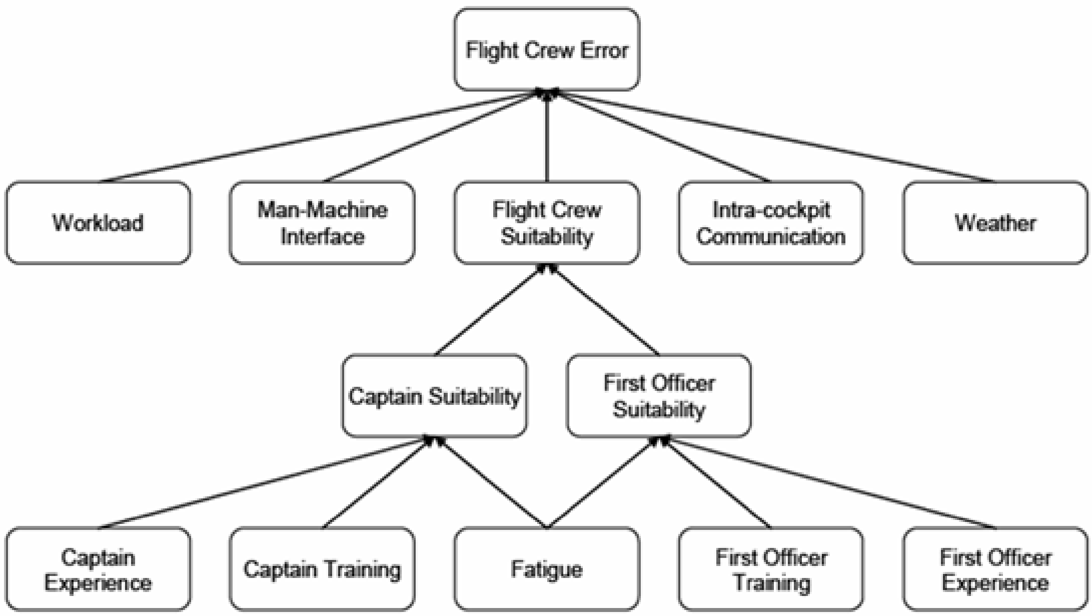


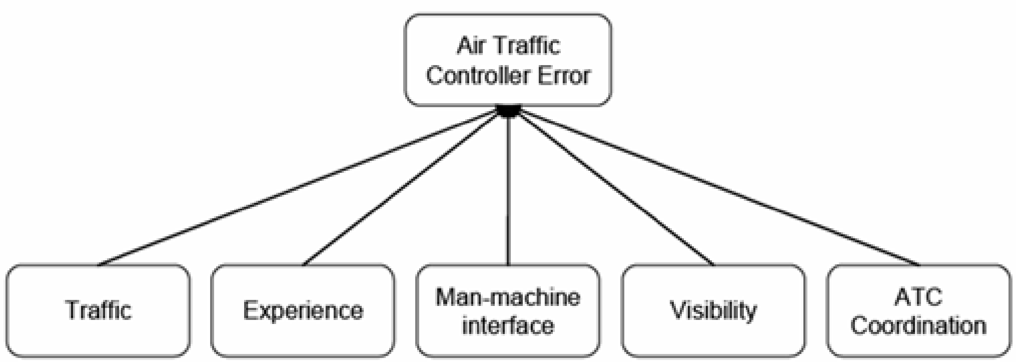
The figure below shows a close-up of the BBN

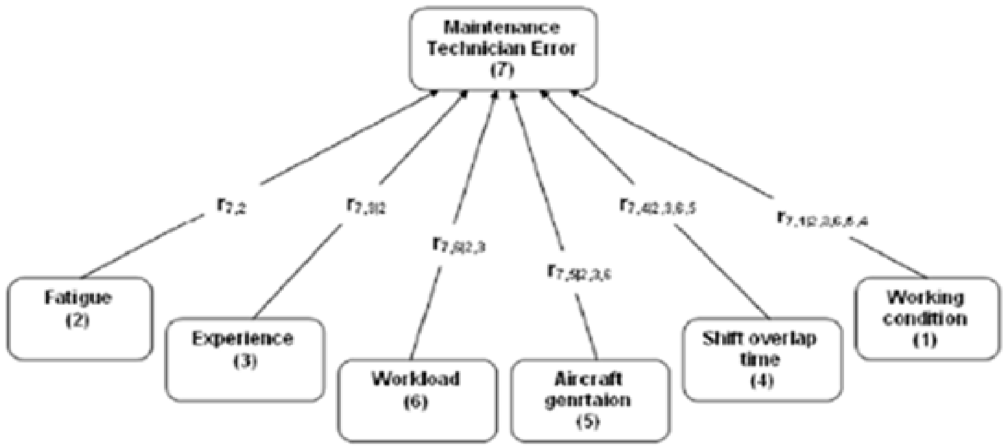


Human performance models

The following figures show the BBNs for each model

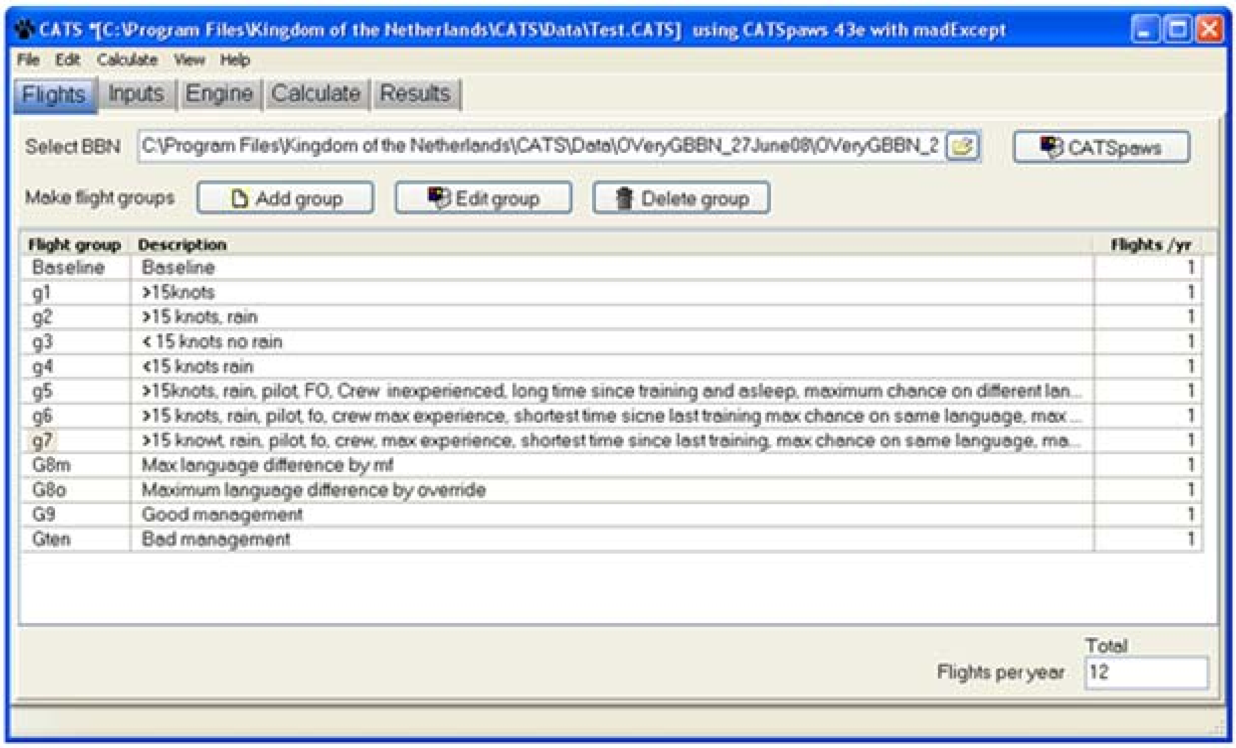





Maintenance
Technician Error
(7)
$r_{7,2}$
$r_{7,3|2}$
$r_{7,6|2,3}$
$r_{7,5|2,3,6}$
$r_{7,4|2,3,6,5}$
$r_{7,1|2,3,6,5,4}$
Fatigue
(2)
Experience
(3)
Workload
(6)
Aircraft
genrtaion
(5)
Shift overlap
time
(4)
Working
condition
(1)

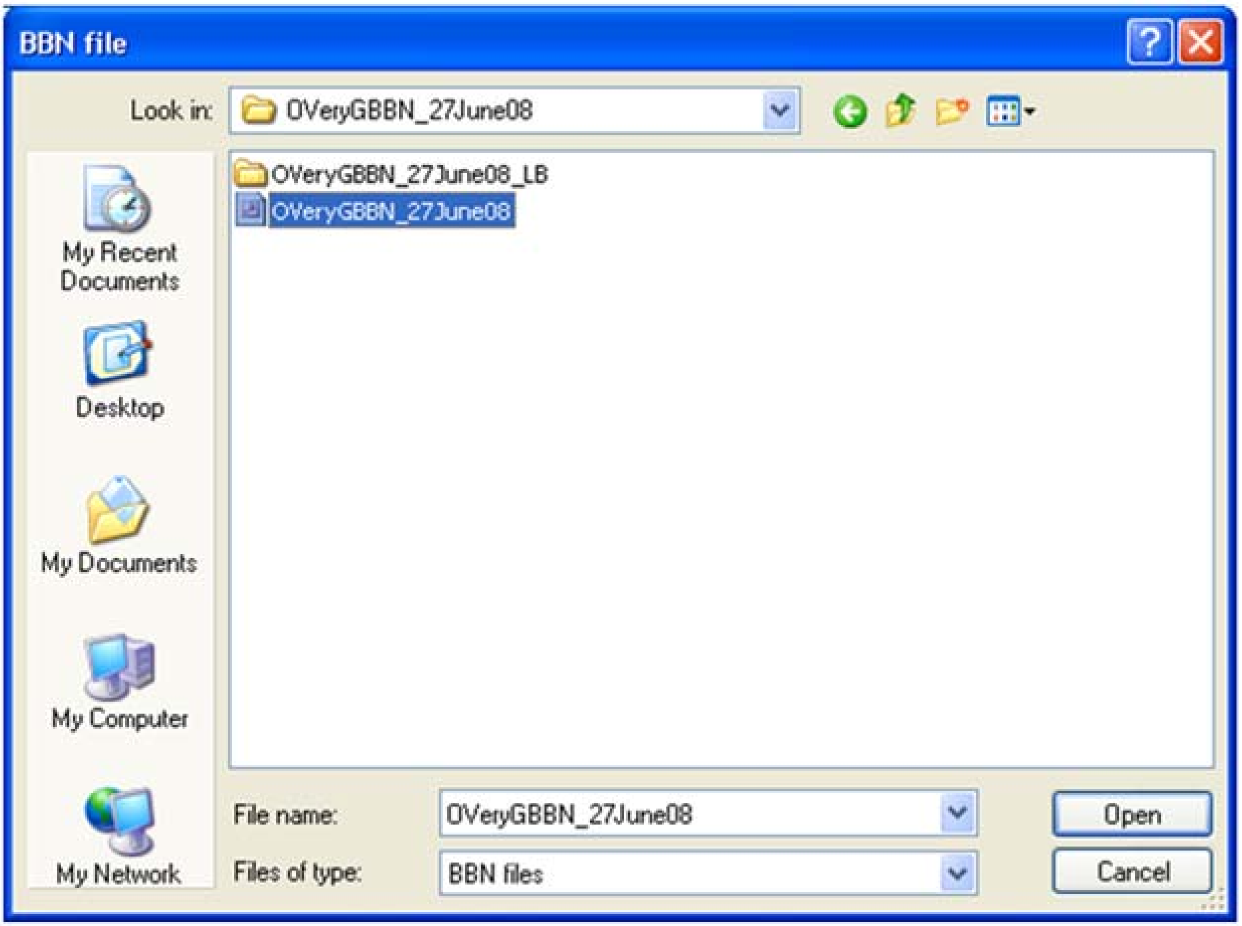
Step1 Flight groups

The figure below shows the flight groups tab.



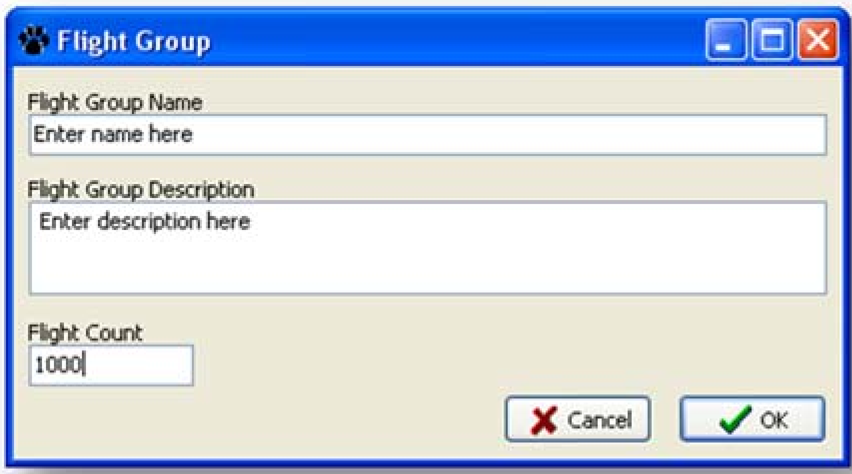
Select BBN

Click on the folder button to the right of the file path box to select a different BBN. You might want to do this if the BBN has been updated since the file was last opened.



CATSpaws
This button enables a comparison between the BBN and CATSPAWS and will specify in the paws file where the parameter code and BBN match. Any codes not in CATSpaws will be entered in paws.

Add group button
For setting up a group. Enter name, description and number fo flights



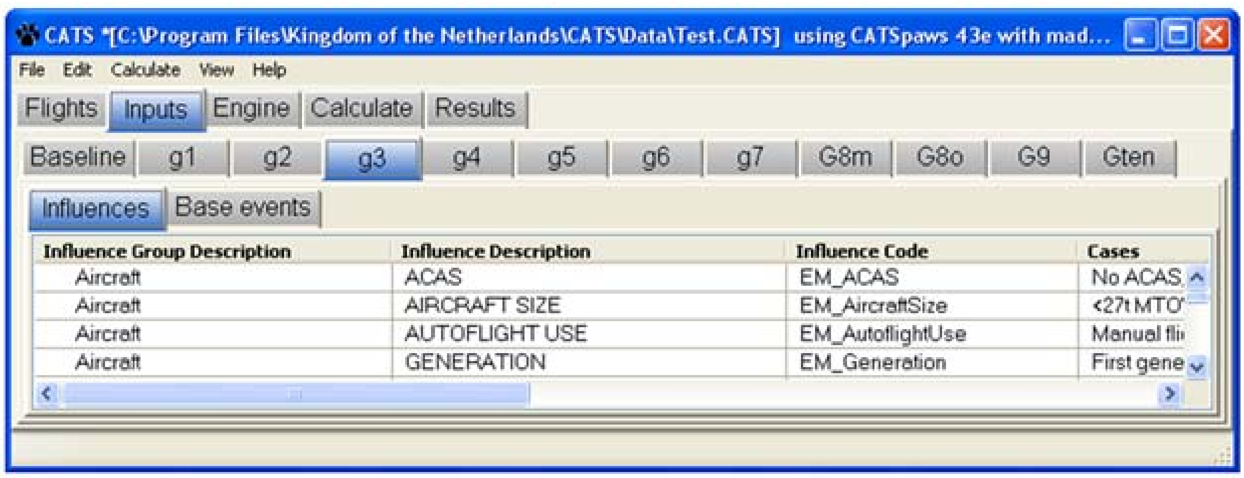
Edit group button
For editing existing group details click on the group then the edit button

Delete group button
For deleting an existing group click on the group then the delete button.

Flight group tabs

Every flight group created appears as a tab in CATS.

By clicking on a group tab the group relevant information appears for each step

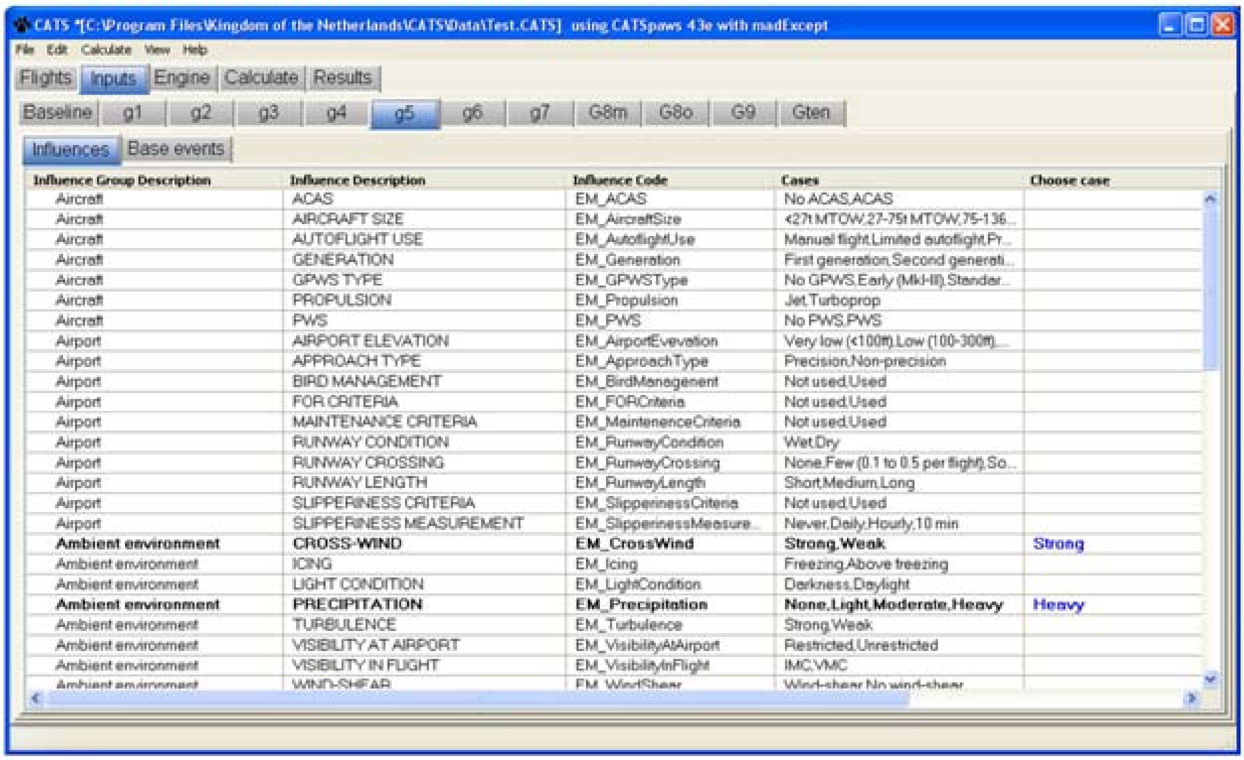


Step 2 Inputs

Inputs has 2 tabs:

Influences

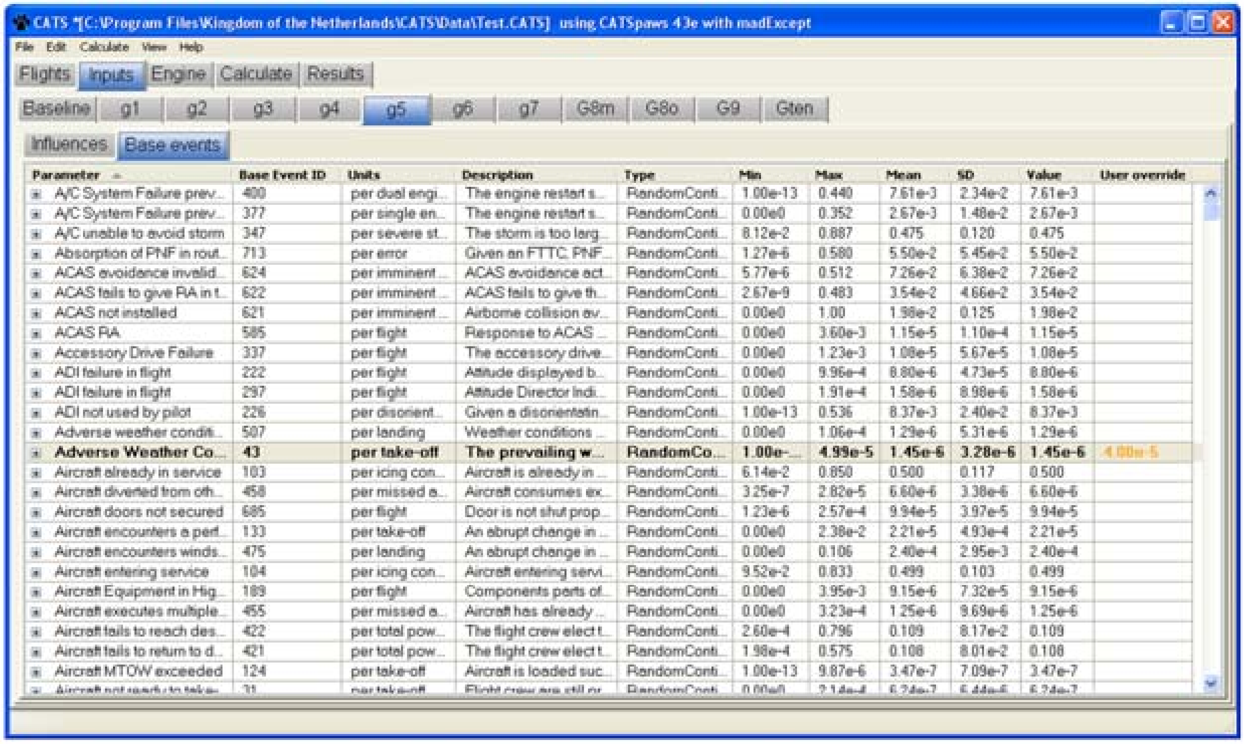
These can be used to modify a number of nodes within the BBN simultaneously. The means and distributions are modified according to predefined mappings



Influence Group Description	Influence Description	Influence Code	Cases	Choose case
Aircraft	ACAS	EM_ACAS	No ACAS,ACAS	
Aircraft	AIRCRAFT SIZE	EM_AircraftSize	<27t MTOW,27-75t MTOW,75-136...	
Aircraft	AUTOFLIGHT USE	EM_AutoflightUse	Manual flight,Limited autoflight,Pr...	
Aircraft	GENERATION	EM_Generation	First generation,Second generati...	
Aircraft	GPWS TYPE	EM_GPWSType	No GPWS,Early (MkI-III),Standar...	
Aircraft	PROPULSION	EM_Propulsion	Jet,Turboprop	
Aircraft	PWS	EM_PWS	No PWS,PWS	
Airport	AIRPORT ELEVATION	EM_AirportEvevation	Very low (<100ft),Low (100-300ft)...	
Airport	APPROACH TYPE	EM_ApproachType	Precision,Non-precision	
Airport	BIRD MANAGEMENT	EM_BirdManagenent	Not used,Used	
Airport	FOR CRITERIA	EM_FORCriteria	Not used,Used	
Airport	MAINTENANCE CRITERIA	EM_MaintenenceCriteria	Not used,Used	
Airport	RUNWAY CONDITION	EM_RunwayCondition	Wet,Dry	
Airport	RUNWAY CROSSING	EM_RunwayCrossing	None,Few (0.1 to 0.5 per flight),So...	
Airport	RUNWAY LENGTH	EM_RunwayLength	Short,Medium,Long	
Airport	SLIPPERINESS CRITERIA	EM_SlipperinessCriteria	Not used,Used	
Airport	SLIPPERINESS MEASUREMENT	EM_SlipperinessMeasure...	Never,Daily,Hourly,10 min	
Ambient environment	**CROSS-WIND**	**EM_CrossWind**	**Strong,Weak**	**Strong**
Ambient environment	ICING	EM_Icing	Freezing,Above freezing	
Ambient environment	LIGHT CONDITION	EM_LightCondition	Darkness,Daylight	
Ambient environment	**PRECIPITATION**	**EM_Precipitation**	**None,Light,Moderate,Heavy**	**Heavy**
Ambient environment	TURBULENCE	EM_Turbulence	Strong,Weak	
Ambient environment	VISIBILITY AT AIRPORT	EM_VisibilityAtAirport	Restricted,Unrestricted	
Ambient environment	VISIBILITY IN FLIGHT	EM_VisibilityInFlight	IMC,VMC	
Ambient environment	WIND-SHEAR	EM_WindShear	Wind-shear,No wind-shear	

Base events

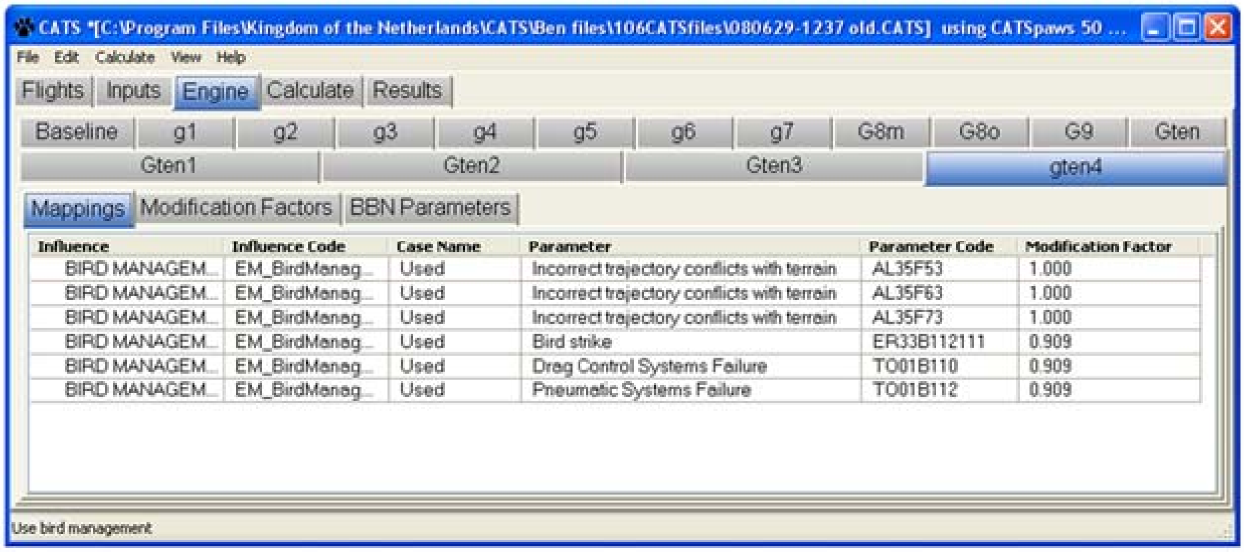
These can be used to override current values of base events (Fault tree) and base iunfluences (Human performance BBNs)


CATS *[C:\Program Files\Kingdom of the Netherlands\CATS\Data\Test.CATS] using CATSpaws 43e with madExcept
File Edit Calculate View Help
Flights Inputs Engine Calculate Results
Baseline g1 g2 g3 g4 g5 g6 g7 G8m G8o G9 Gten
Influences Base events
Parameter Base Event ID Units Description Type Min Max Mean SD Value User override
A/C System Failure prev... 400 per dual engi... The engine restart s... RandomConti... 1.00e-13 0.440 7.61e-3 2.34e-2 7.61e-3
A/C System Failure prev... 377 per single en... The engine restart s... RandomConti... 0.00e0 0.352 2.67e-3 1.48e-2 2.67e-3
A/C unable to avoid storm 347 per severe st... The storm is too larg... RandomConti... 8.12e-2 0.887 0.475 0.120 0.475
Absorption of PNF in rout... 713 per error Given an FTTC, PNF... RandomConti... 1.27e-6 0.580 5.50e-2 5.45e-2 5.50e-2
ACAS avoidance invalid... 624 per imminent ... ACAS avoidance act... RandomConti... 5.77e-6 0.512 7.26e-2 6.38e-2 7.26e-2
ACAS fails to give RA in t... 622 per imminent ... ACAS fails to give th... RandomConti... 2.67e-9 0.483 3.54e-2 4.66e-2 3.54e-2
ACAS not installed 621 per imminent ... Airborne collision av... RandomConti... 0.00e0 1.00 1.98e-2 0.125 1.98e-2
ACAS RA 585 per flight Response to ACAS ... RandomConti... 0.00e0 3.60e-3 1.15e-5 1.10e-4 1.15e-5
Accessory Drive Failure 337 per flight The accessory drive... RandomConti... 0.00e0 1.23e-3 1.08e-5 5.67e-5 1.08e-5
ADI failure in flight 222 per flight Attitude displayed b... RandomConti... 0.00e0 9.96e-4 8.80e-6 4.73e-5 8.80e-6
ADI failure in flight 297 per flight Attitude Director Indi... RandomConti... 0.00e0 1.91e-4 1.58e-6 8.98e-6 1.58e-6
ADI not used by pilot 226 per disorient... Given a disorientatin... RandomConti... 1.00e-13 0.536 8.37e-3 2.40e-2 8.37e-3
Adverse weather conditi... 507 per landing Weather conditions ... RandomConti... 0.00e0 1.06e-4 1.29e-6 5.31e-6 1.29e-6
Adverse Weather Co... 43 per take-off The prevailing w... RandomCo... 1.00e-... 4.99e-5 1.45e-6 3.28e-6 1.45e-6 4.00e-5
Aircraft already in service 103 per icing con... Aircraft is already in ... RandomConti... 6.14e-2 0.850 0.500 0.117 0.500
Aircraft diverted from oth... 458 per missed a... Aircraft consumes ex... RandomConti... 3.25e-7 2.82e-5 6.60e-6 3.38e-6 6.60e-6
Aircraft doors not secured 685 per flight Door is not shut prop... RandomConti... 1.23e-6 2.57e-4 9.94e-5 3.97e-5 9.94e-5
Aircraft encounters a perf... 133 per take-off An abrupt change in ... RandomConti... 0.00e0 2.38e-2 2.21e-5 4.93e-4 2.21e-5
Aircraft encounters winds... 475 per landing An abrupt change in ... RandomConti... 0.00e0 0.106 2.40e-4 2.95e-3 2.40e-4
Aircraft entering service 104 per icing con... Aircraft entering servi... RandomConti... 9.52e-2 0.833 0.499 0.103 0.499
Aircraft Equipment in Hig... 189 per flight Components parts of... RandomConti... 0.00e0 3.95e-3 9.15e-6 7.32e-5 9.15e-6
Aircraft executes multiple... 455 per missed a... Aircraft has already ... RandomConti... 0.00e0 3.23e-4 1.25e-6 9.69e-6 1.25e-6
Aircraft fails to reach des... 422 per total pow... The flight crew elect t... RandomConti... 2.60e-4 0.796 0.109 8.17e-2 0.109
Aircraft fails to return to d... 421 per total pow... The flight crew elect t... RandomConti... 1.98e-4 0.575 0.108 8.01e-2 0.108
Aircraft MTOW exceeded 124 per take-off Aircraft is loaded suc... RandomConti... 1.00e-13 9.87e-6 3.47e-7 7.09e-7 3.47e-7

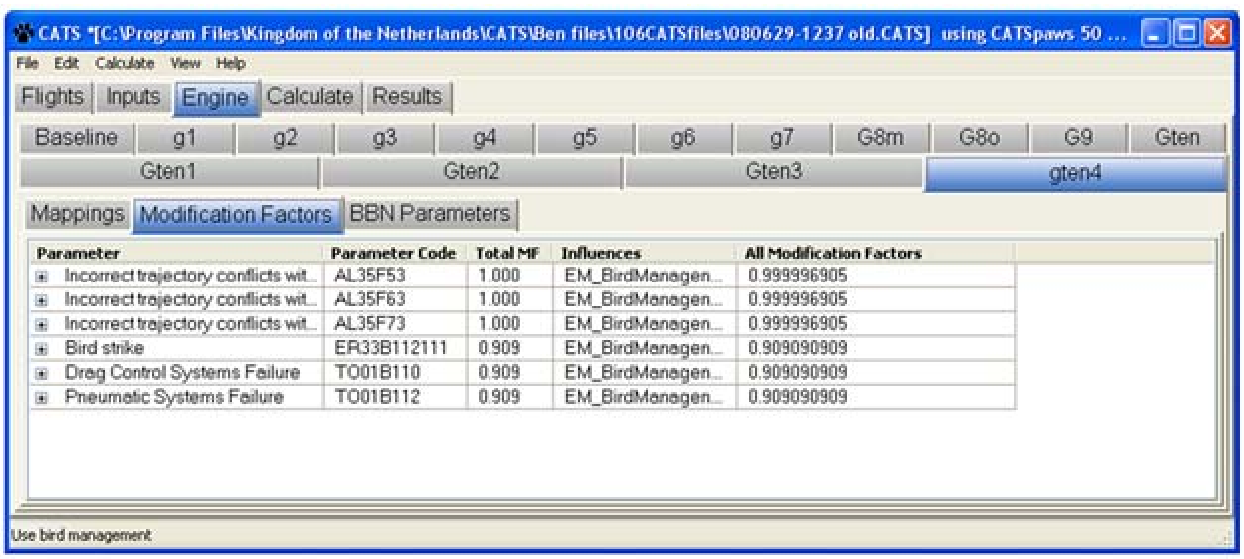
Step 3 Engine

When the engine tab is selected, 3 sub tabs become available.

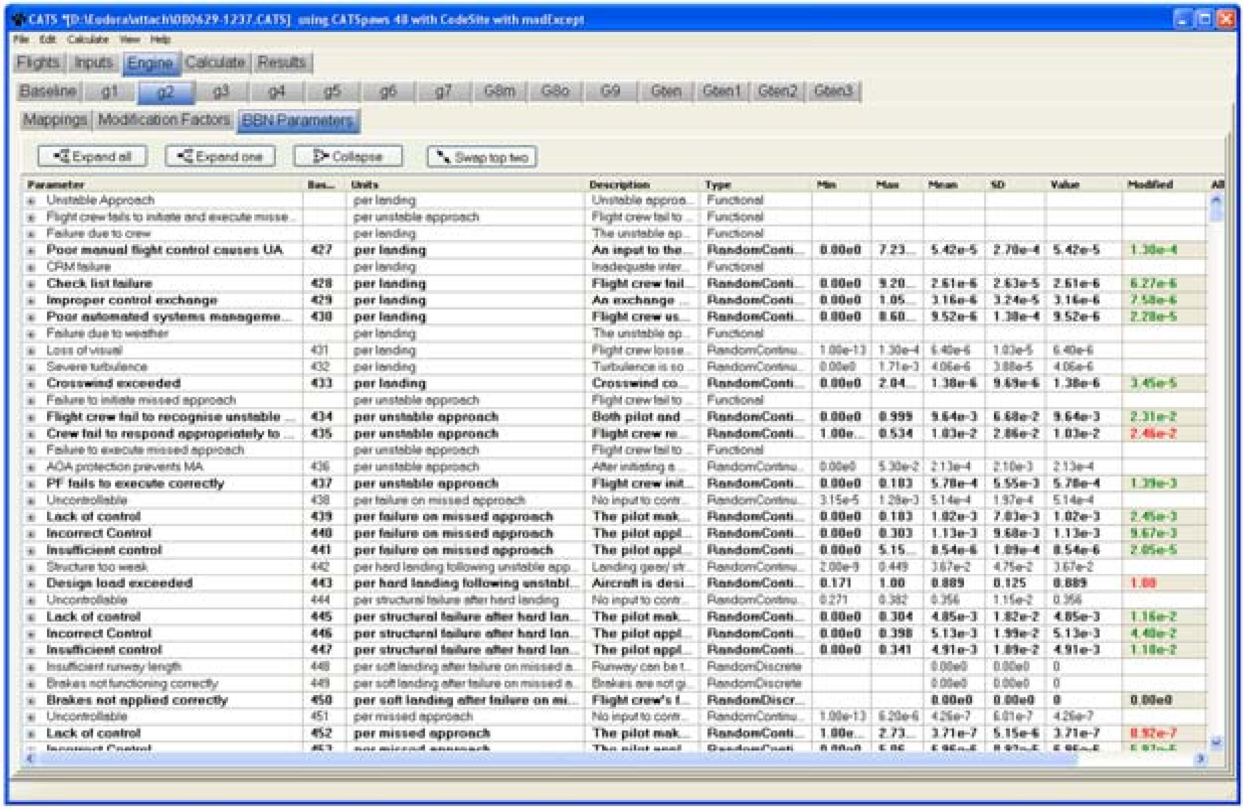
Mappings
These show the effects of any influences from Step 2 on the BBN nodes, including the modification factor



Modification factors:



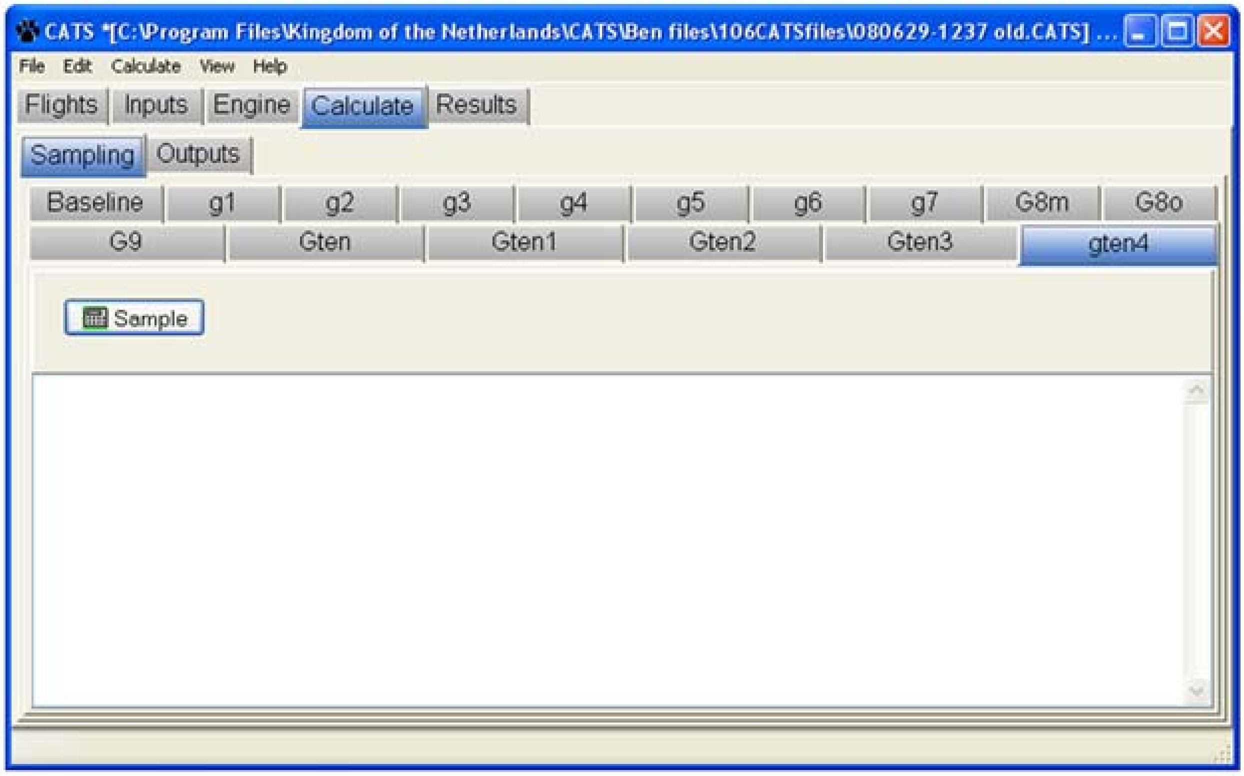
BBN Parameters - the nodes in the BBN



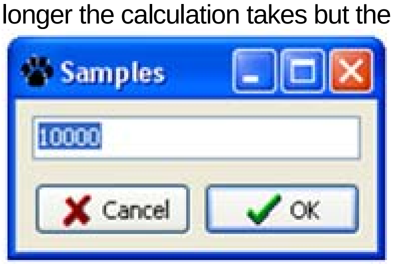
Parameter	Bas...	Units	Description	Type	Min	Max	Mean	SD	Value	Modified
Unstable Approach		per landing	Unstable approa...	Functional						
Flight crew fails to initiate and execute misse...		per unstable approach	Flight crew fail to ...	Functional						
Failure due to crew		per landing	The unstable ap...	Functional						
Poor manual flight control causes UA	**427**	**per landing**	**An input to the...**	**RandomConti...**	**0.00e0**	**7.23...**	**5.42e-5**	**2.70e-4**	**5.42e-5**	1.30e-4
CRM failure		per landing	Inadequate inter...	Functional						
Check list failure	**428**	**per landing**	**Flight crew fail...**	**RandomConti...**	**0.00e0**	**9.20...**	**2.61e-6**	**2.63e-5**	**2.61e-6**	6.27e-6
Improper control exchange	**429**	**per landing**	**An exchange ...**	**RandomConti...**	**0.00e0**	**1.05...**	**3.16e-6**	**3.24e-5**	**3.16e-6**	7.58e-6
Poor automated systems manageme...	**430**	**per landing**	**Flight crew us...**	**RandomConti...**	**0.00e0**	**8.60...**	**9.52e-6**	**1.30e-4**	**9.52e-6**	2.28e-5
Failure due to weather		per landing	The unstable ap...	Functional						
Loss of visual	431	per landing	Flight crew losse...	RandomContinu...	1.00e-13	1.30e-4	6.40e-6	1.03e-5	6.40e-6	
Severe turbulence	432	per landing	Turbulence is so ...	RandomContinu...	0.00e0	1.71e-3	4.06e-6	3.88e-5	4.06e-6	
Crosswind exceeded	**433**	**per landing**	**Crosswind co...**	**RandomConti...**	**0.00e0**	**2.04...**	**1.38e-6**	**9.69e-6**	**1.38e-6**	3.45e-5
Failure to initiate missed approach		per unstable approach	Flight crew fail to ...	Functional						
Flight crew fail to recognise unstable ...	**434**	**per unstable approach**	**Both pilot and ...**	**RandomConti...**	**0.00e0**	**0.999**	**9.64e-3**	**6.68e-2**	**9.64e-3**	2.31e-2
Crew fail to respond appropriately to ...	**435**	**per unstable approach**	**Flight crew re...**	**RandomConti...**	**1.00e...**	**0.534**	**1.03e-2**	**2.86e-2**	**1.03e-2**	2.46e-2
Failure to execute missed approach		per unstable approach	Flight crew fail to ...	Functional						
AOA protection prevents MA	436	per unstable approach	After initiating a ...	RandomContinu...	0.00e0	5.30e-2	2.13e-4	2.10e-3	2.13e-4	
PF fails to execute correctly	**437**	**per unstable approach**	**Flight crew init...**	**RandomConti...**	**0.00e0**	**0.183**	**5.78e-4**	**5.55e-3**	**5.78e-4**	1.39e-3
Uncontrollable	438	per failure on missed approach	No input to contr...	RandomContinu...	3.15e-5	1.28e-3	5.14e-4	1.97e-4	5.14e-4	
Lack of control	**439**	**per failure on missed approach**	**The pilot mak...**	**RandomConti...**	**0.00e0**	**0.183**	**1.02e-3**	**7.03e-3**	**1.02e-3**	2.45e-3
Incorrect Control	**440**	**per failure on missed approach**	**The pilot appl...**	**RandomConti...**	**0.00e0**	**0.303**	**1.13e-3**	**9.68e-3**	**1.13e-3**	9.67e-3
Insufficient control	**441**	**per failure on missed approach**	**The pilot appl...**	**RandomConti...**	**0.00e0**	**5.15...**	**8.54e-6**	**1.09e-4**	**8.54e-6**	2.05e-5
Structure too weak	442	per hard landing following unstable app...	Landing gear/ str...	RandomContinu...	2.00e-9	0.449	3.67e-2	4.75e-2	3.67e-2	
Design load exceeded	**443**	**per hard landing following unstabl...**	**Aircraft is desi...**	**RandomConti...**	**0.171**	**1.00**	**0.889**	**0.125**	**0.889**	1.00
Uncontrollable	444	per structural failure after hard landing	No input to contr...	RandomContinu...	0.271	0.382	0.356	1.15e-2	0.356	
Lack of control	**445**	**per structural failure after hard lan...**	**The pilot mak...**	**RandomConti...**	**0.00e0**	**0.304**	**4.85e-3**	**1.82e-2**	**4.85e-3**	1.16e-2
Incorrect Control	**446**	**per structural failure after hard lan...**	**The pilot appl...**	**RandomConti...**	**0.00e0**	**0.398**	**5.13e-3**	**1.99e-2**	**5.13e-3**	4.40e-2
Insufficient control	**447**	**per structural failure after hard lan...**	**The pilot appl...**	**RandomConti...**	**0.00e0**	**0.341**	**4.91e-3**	**1.89e-2**	**4.91e-3**	1.18e-2
Insufficient runway length	448	per soft landing after failure on missed a...	Runway can be t...	RandomDiscrete			0.00e0	0.00e0	0	
Brakes not functioning correctly	449	per soft landing after failure on missed a...	Brakes are not gi...	RandomDiscrete			0.00e0	0.00e0	0	
Brakes not applied correctly	**450**	**per soft landing after failure on mi...**	**Flight crew's f...**	**RandomDiscr...**			**0.00e0**	**0.00e0**	**0**	**0.00e0**
Uncontrollable	451	per missed approach	No input to contr...	RandomContinu...	1.00e-13	6.20e-6	4.26e-7	6.01e-7	4.26e-7	
Lack of control	**452**	**per missed approach**	**The pilot mak...**	**RandomConti...**	**1.00e...**	**2.73...**	**3.71e-7**	**5.15e-6**	**3.71e-7**	8.92e-7

Step 4 Calculate

The calculate screen is blank when no previous calculations have been performed. Whether or not the screen is blank a calculation can be performed either to calculate from scratch or to update a previous calculation.

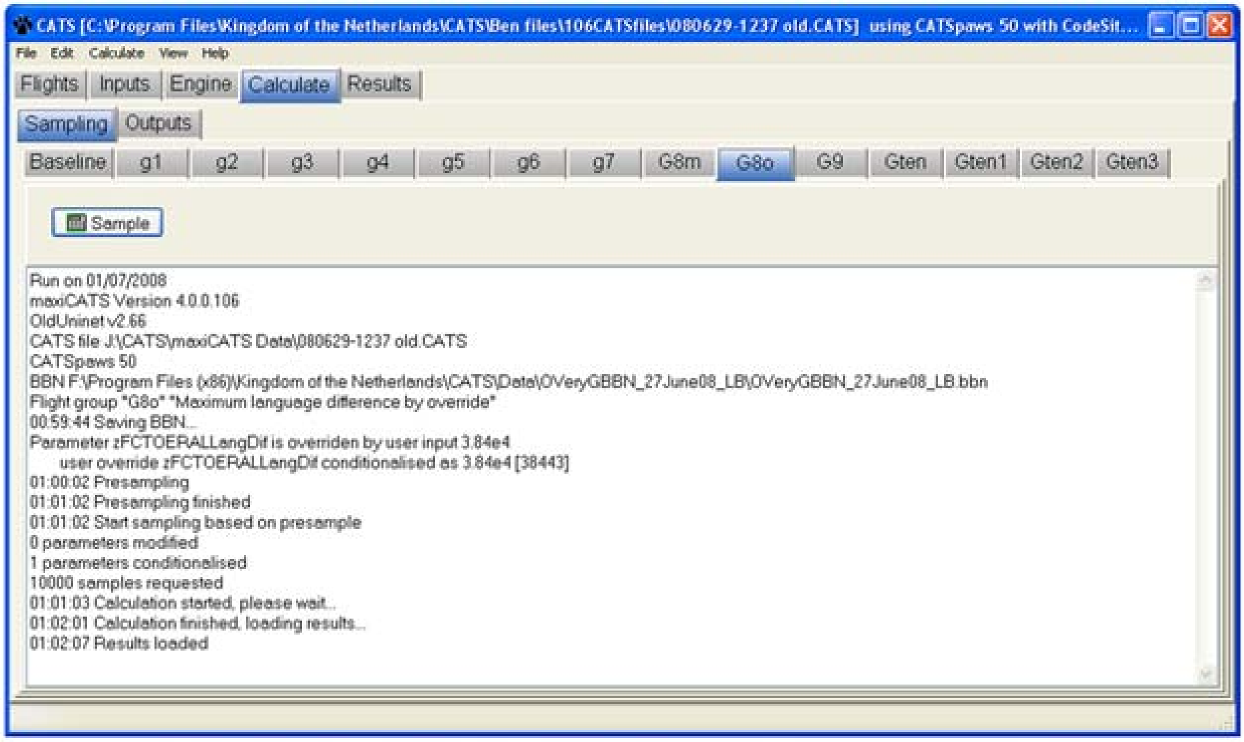


To perform a calculation either:
a) To do all flight groups in one group - use the Calculate drop down menu and select All flight groups and then the number of samples (see b), or
b) click on button Sample with the selected flight group tab. The more samples that are chosen, the longer the calculation takes but the more accurate the results.



The performance of the calculation creates a log and, if successful a window appears which says results available. Click on OK and go to the Results tab.

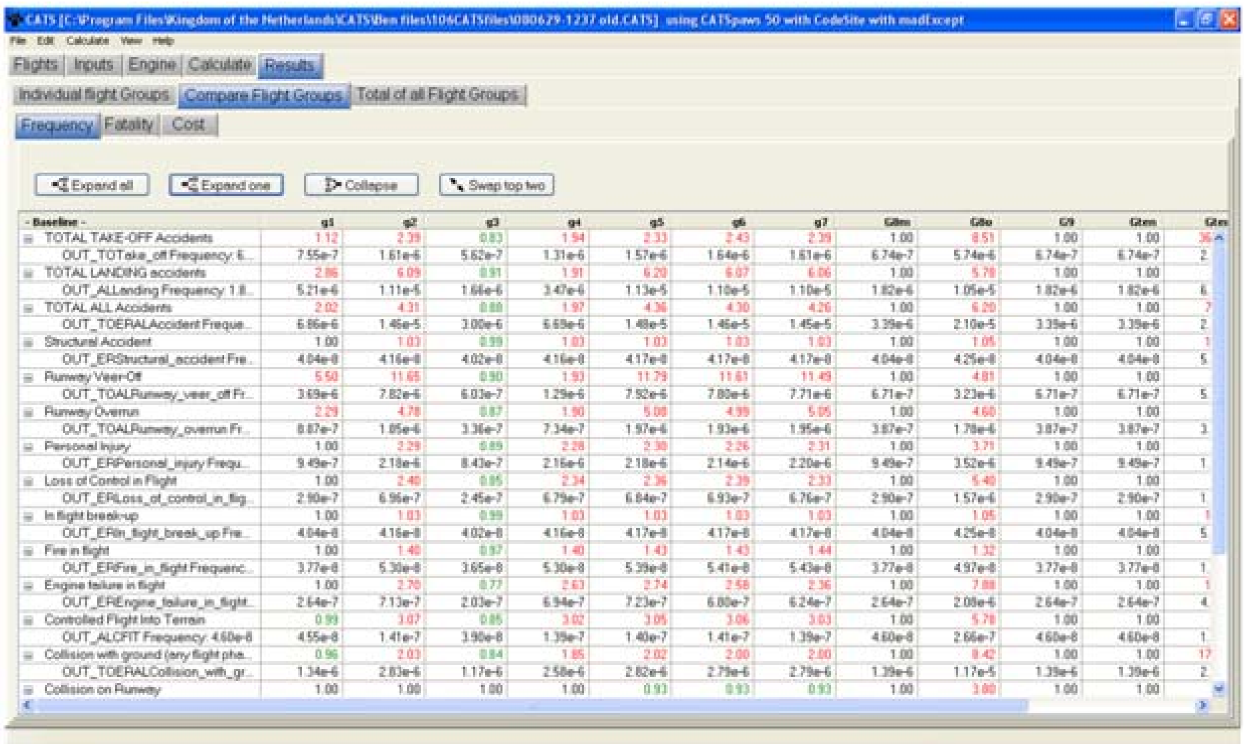
Log of the calculation:



Step 5 Results

Results has a large number of sub tabs enabling different presentations of the results.
<u>Individual flight groups:</u>
For every flight group the following results are available:

Nodes Per ESD per flight phase
Output nodes
End nodes
Base events
Modified nodes



- Baseline -	g1	g2	g3	g4	g5	g6	g7	G8m	G8o	G9	Gtem	Gtem
TOTAL TAKE-OFF Accidents	1.12	2.39	0.83	1.94	2.33	2.43	2.39	1.00	8.51	1.00	1.00	36
OUT_TOTake_off Frequency: 6...	7.55e-7	1.61e-6	5.62e-7	1.31e-6	1.57e-6	1.64e-6	1.61e-6	6.74e-7	5.74e-6	6.74e-7	6.74e-7	2
TOTAL LANDING accidents	2.86	6.09	0.91	1.91	6.20	6.07	6.06	1.00	5.78	1.00	1.00	
OUT_ALLanding Frequency: 1.8...	5.21e-6	1.11e-5	1.66e-6	3.47e-6	1.13e-5	1.10e-5	1.10e-5	1.82e-6	1.05e-5	1.82e-6	1.82e-6	6
TOTAL ALL Accidents	2.02	4.31	0.88	1.97	4.36	4.30	4.26	1.00	6.20	1.00	1.00	7
OUT_TOERALAccident Freque...	6.86e-6	1.46e-5	3.00e-6	6.69e-6	1.48e-5	1.46e-5	1.45e-5	3.39e-6	2.10e-5	3.39e-6	3.39e-6	2
Structural Accident	1.00	1.03	0.99	1.03	1.03	1.03	1.03	1.00	1.05	1.00	1.00	1
OUT_ERStructural_accident Fre...	4.04e-8	4.16e-8	4.02e-8	4.16e-8	4.17e-8	4.17e-8	4.17e-8	4.04e-8	4.25e-8	4.04e-8	4.04e-8	5
Runway Veer-Off	5.50	11.65	0.90	1.93	11.79	11.61	11.49	1.00	4.81	1.00	1.00	
OUT_TOALRunway_veer_off Fr...	3.69e-6	7.82e-6	6.03e-7	1.29e-6	7.92e-6	7.80e-6	7.71e-6	6.71e-7	3.23e-6	6.71e-7	6.71e-7	5
Runway Overrun	2.29	4.78	0.87	1.90	5.08	4.99	5.05	1.00	4.60	1.00	1.00	
OUT_TOALRunway_overrun Fr...	8.87e-7	1.05e-6	3.36e-7	7.34e-7	1.97e-6	1.93e-6	1.95e-6	3.87e-7	1.78e-6	3.87e-7	3.87e-7	3
Personal Injury	1.00	2.29	0.89	2.28	2.30	2.26	2.31	1.00	3.71	1.00	1.00	
OUT_ERPersonal_injury Frequ...	9.49e-7	2.18e-6	8.43e-7	2.16e-6	2.18e-6	2.14e-6	2.20e-6	9.49e-7	3.52e-6	9.49e-7	9.49e-7	1
Loss of Control in Flight	1.00	2.40	0.85	2.34	2.36	2.39	2.33	1.00	5.40	1.00	1.00	
OUT_ERLoss_of_control_in_flig...	2.90e-7	6.96e-7	2.45e-7	6.79e-7	6.84e-7	6.93e-7	6.76e-7	2.90e-7	1.57e-6	2.90e-7	2.90e-7	1
In flight break-up	1.00	1.03	0.99	1.03	1.03	1.03	1.03	1.00	1.05	1.00	1.00	1
OUT_ERIn_flight_break_up Fre...	4.04e-8	4.16e-8	4.02e-8	4.16e-8	4.17e-8	4.17e-8	4.17e-8	4.04e-8	4.25e-8	4.04e-8	4.04e-8	5
Fire in flight	1.00	1.40	0.97	1.40	1.43	1.43	1.44	1.00	1.32	1.00	1.00	
OUT_ERFire_in_flight Frequenc...	3.77e-8	5.30e-8	3.65e-8	5.30e-8	5.39e-8	5.41e-8	5.43e-8	3.77e-8	4.97e-8	3.77e-8	3.77e-8	1
Engine failure in flight	1.00	2.70	0.77	2.63	2.74	2.58	2.36	1.00	7.88	1.00	1.00	1
OUT_EREngine_failure_in_flight...	2.64e-7	7.13e-7	2.03e-7	6.94e-7	7.23e-7	6.00e-7	6.24e-7	2.64e-7	2.08e-6	2.64e-7	2.64e-7	4
Controlled Flight Into Terrain	0.99	3.07	0.85	3.02	3.05	3.06	3.03	1.00	5.78	1.00	1.00	
OUT_ALCFIT Frequency: 4.60e-8	4.55e-8	1.41e-7	3.90e-8	1.39e-7	1.40e-7	1.41e-7	1.39e-7	4.60e-8	2.66e-7	4.60e-8	4.60e-8	1
Collision with ground (any flight pha...	0.96	2.03	0.84	1.85	2.02	2.00	2.00	1.00	8.42	1.00	1.00	17
OUT_TOERALCollision_with_gr...	1.34e-6	2.83e-6	1.17e-6	2.58e-6	2.82e-6	2.79e-6	2.79e-6	1.39e-6	1.17e-5	1.39e-6	1.39e-6	2
Collision on Runway	1.00	1.00	1.00	1.00	0.93	0.93	0.93	1.00	3.00	1.00	1.00	

Fatality and Costs

Fatalities and costs can be seen on the Results tab
1) Fatalities and costs appear as columns in the Data displays
2) when Compare Flight Groups are chosen a fatalities and a costs button appear