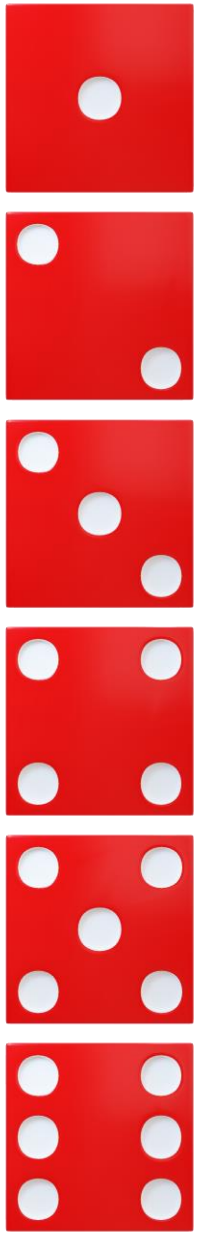
Risk of Loss in Allocation Systems

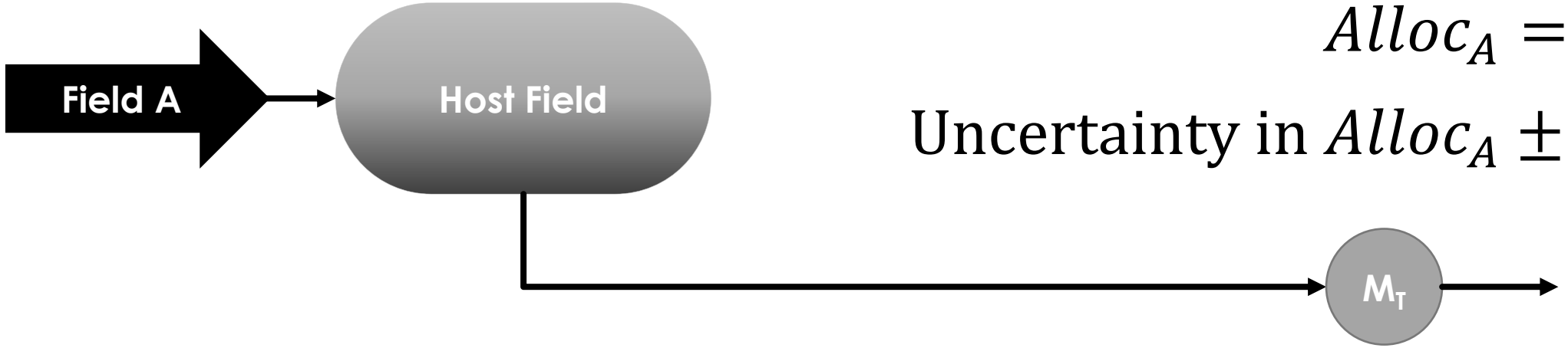
1st June 2023



- Simple Example
- Risk and Return
- Uncertainty and the Normal Distribution
- Risk and Loss Aversion
- Integrated Risk of Loss
- Conclusions

Simple Example

Simple Process



$$Alloc_A = M_T$$

Uncertainty in $Alloc_A$ $\pm 1\%$

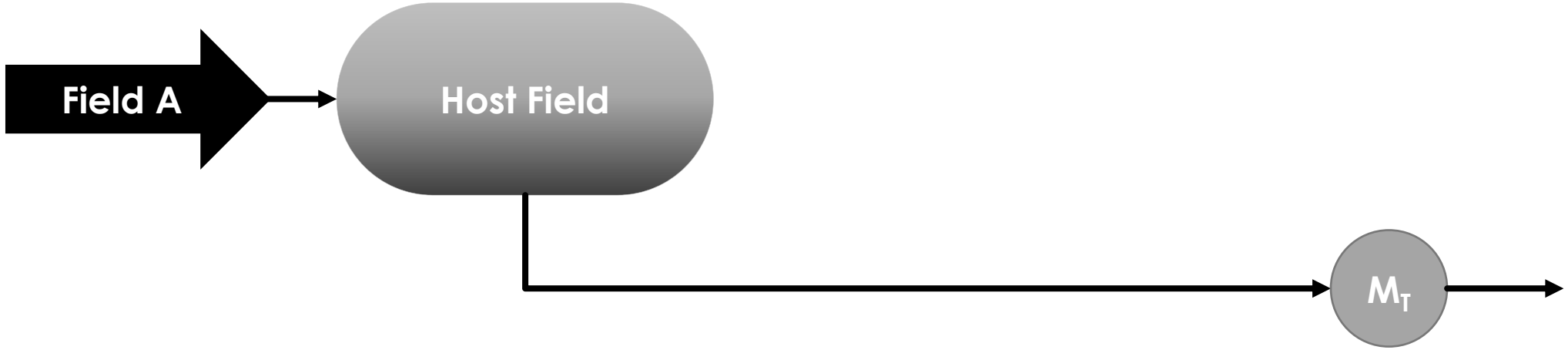
M_T =1,000 te/d

Uncertainty in M_T $\pm 1\%$

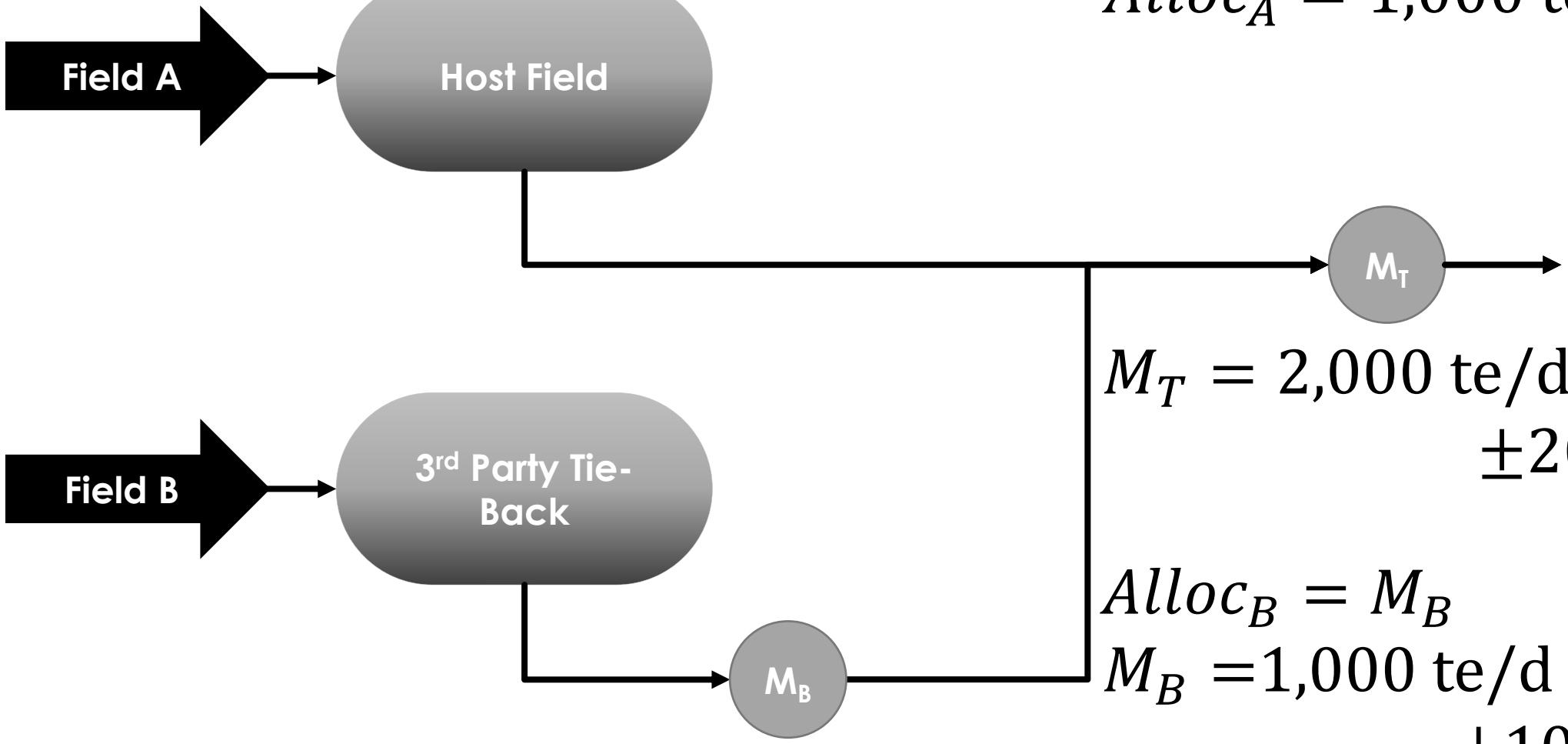
± 10 te/d

Uncertainty expressed at the 95% confidence level !

Simple Process New Field



Simple Process New Field



$$Alloc_A = M_T - M_B$$

$$Alloc_A = 1{,}000 \text{ te/d } \pm 2.2\%$$

$$\pm 22 \text{ te/d}$$

$$M_T = 2{,}000 \text{ te/d } \pm 1\%$$

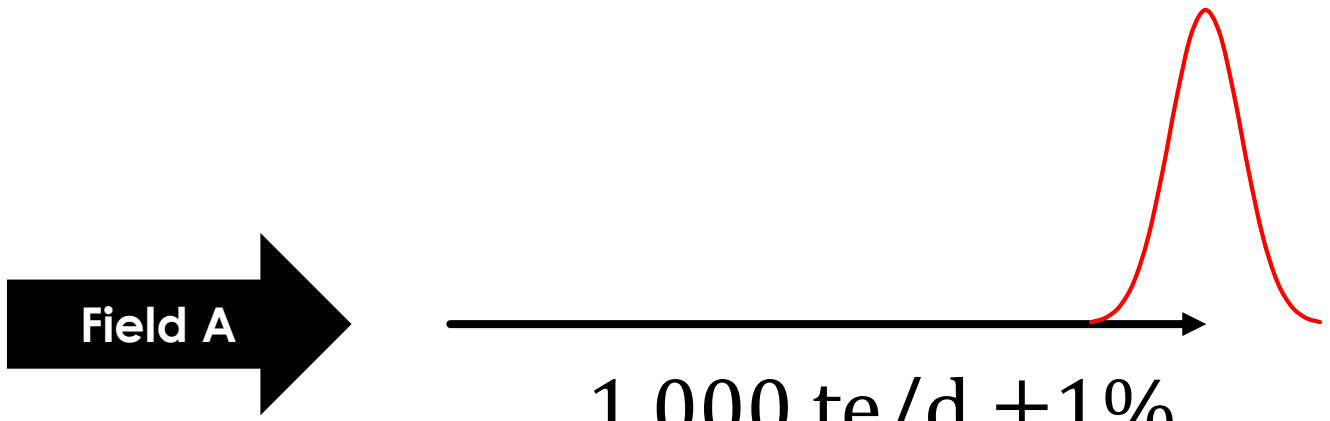
$$\pm 20 \text{ te/d}$$

$$Alloc_B = M_B$$

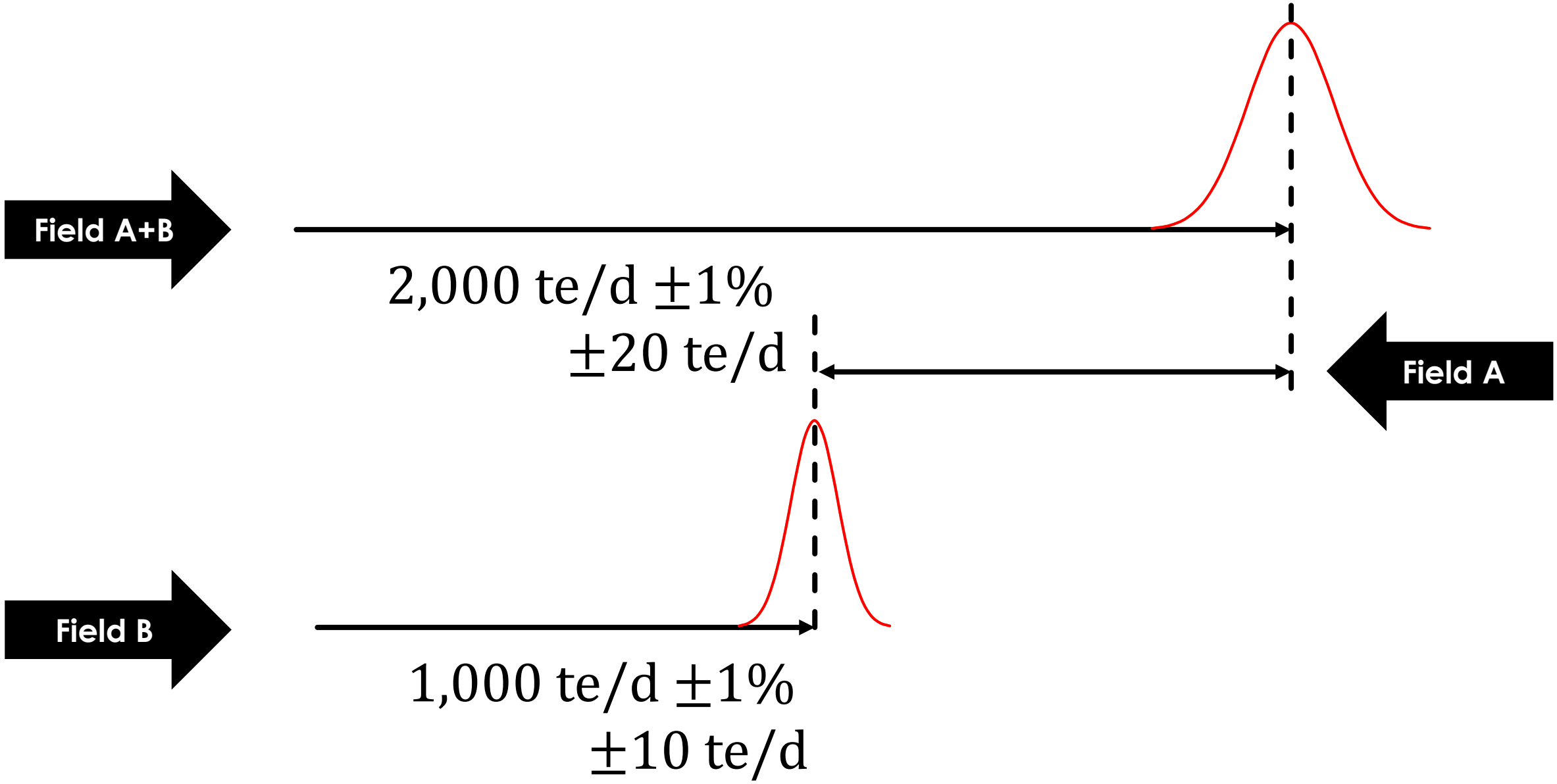
$$M_B = 1{,}000 \text{ te/d } \pm 1\%$$

$$\pm 10 \text{ te/d}$$

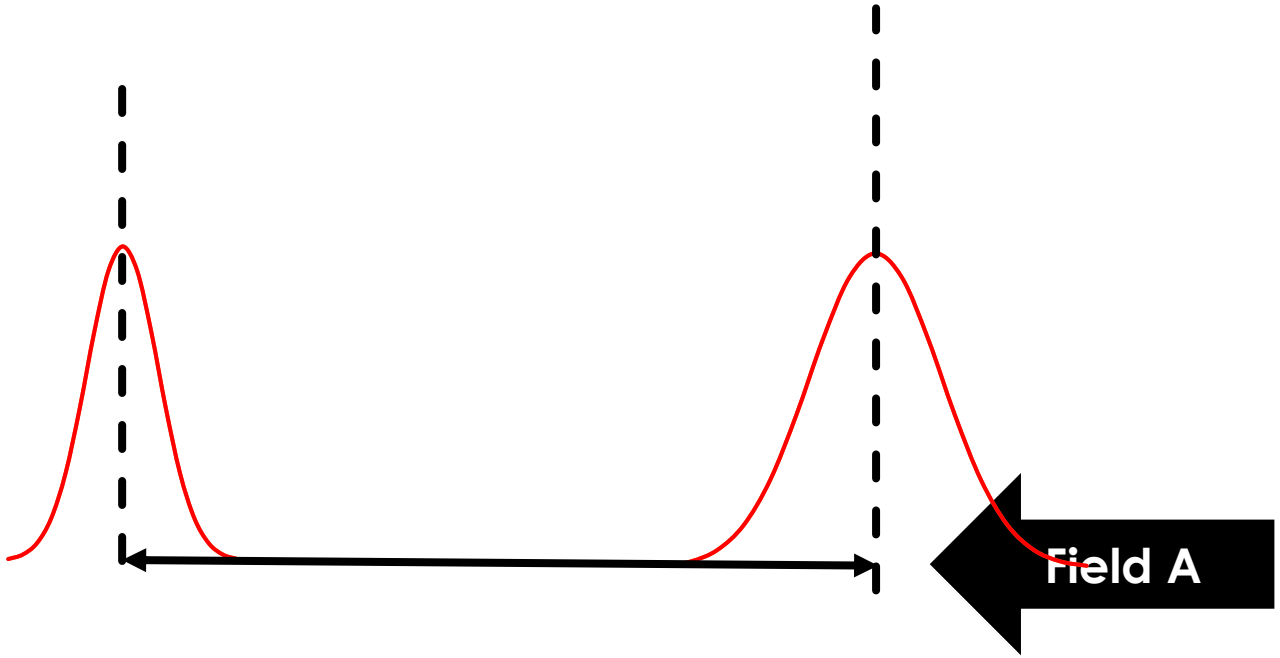
Simple Process New Field



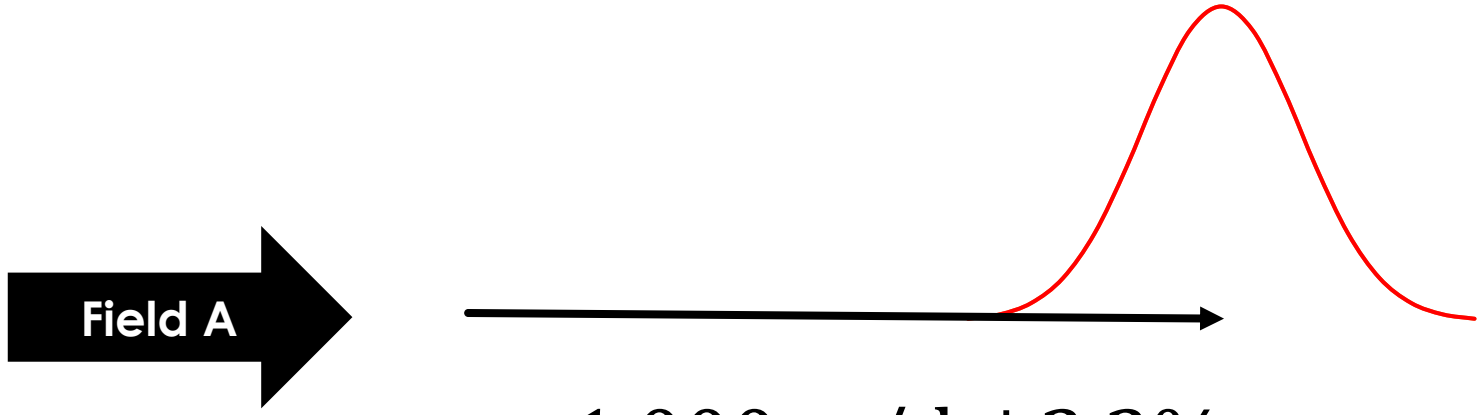
Simple Process New Field

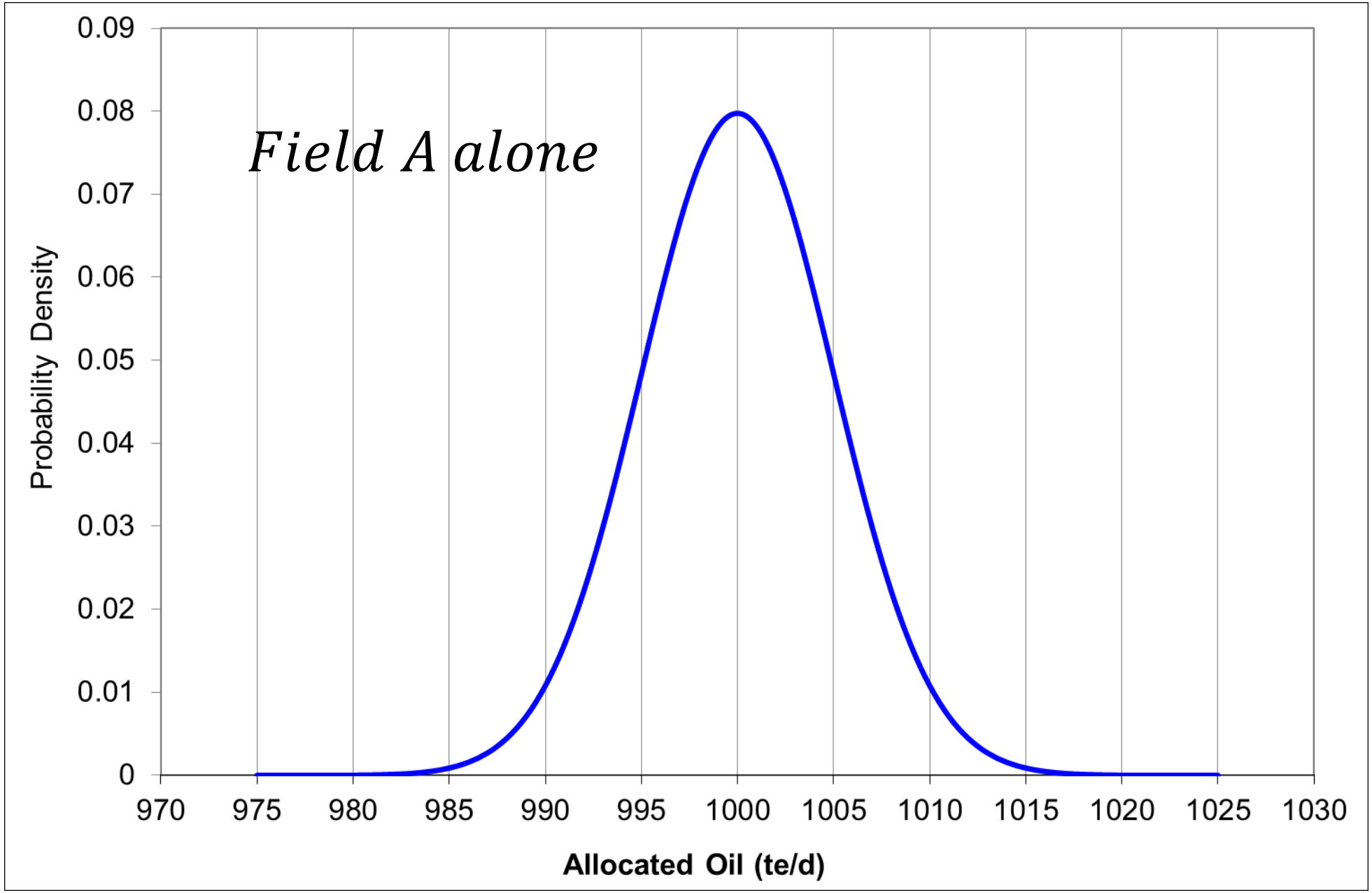


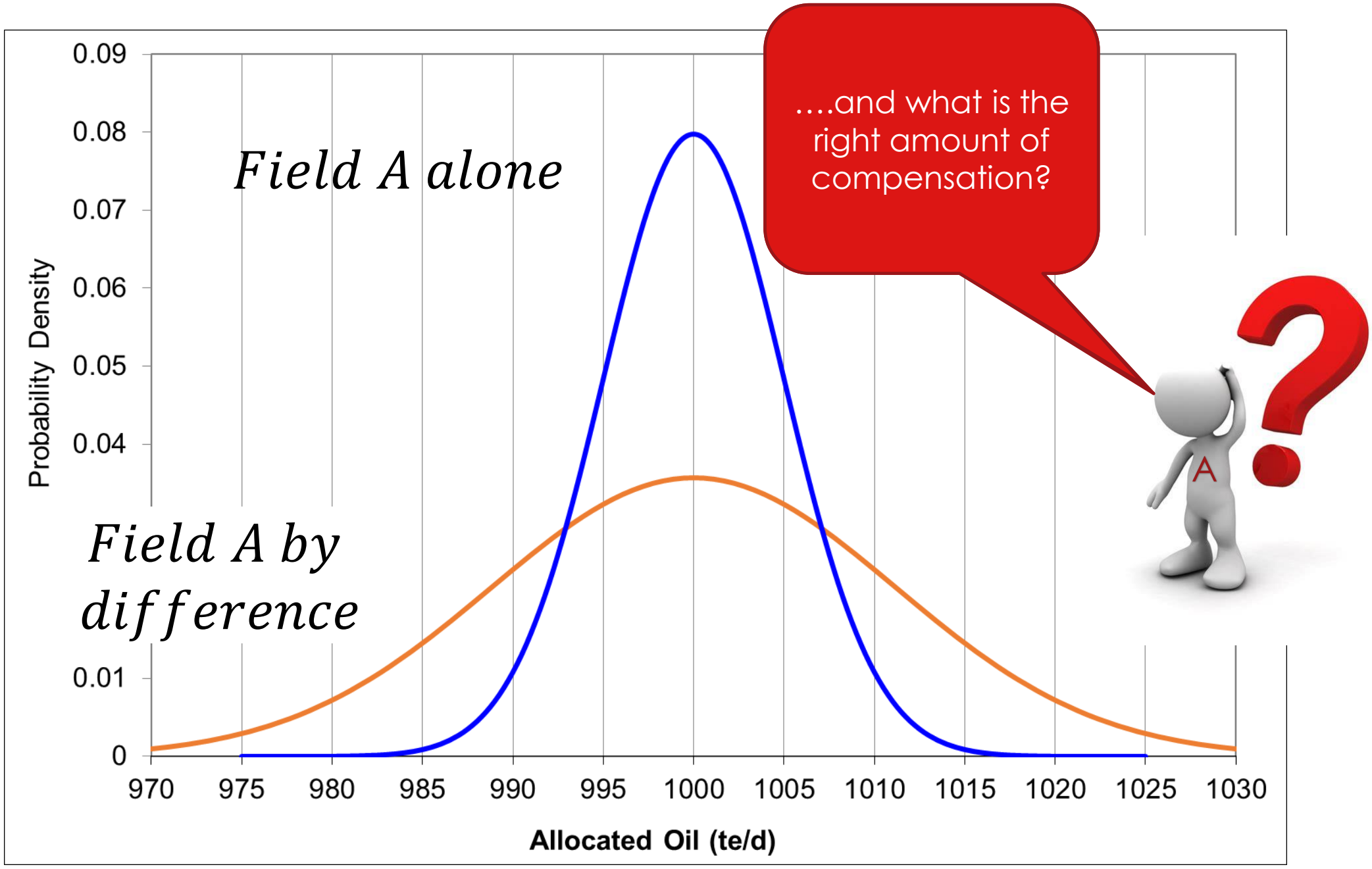
Simple Process New Field

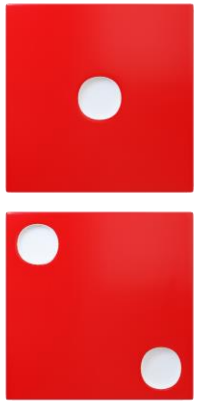


Simple Process New Field




Field A alone
Probability Density
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)

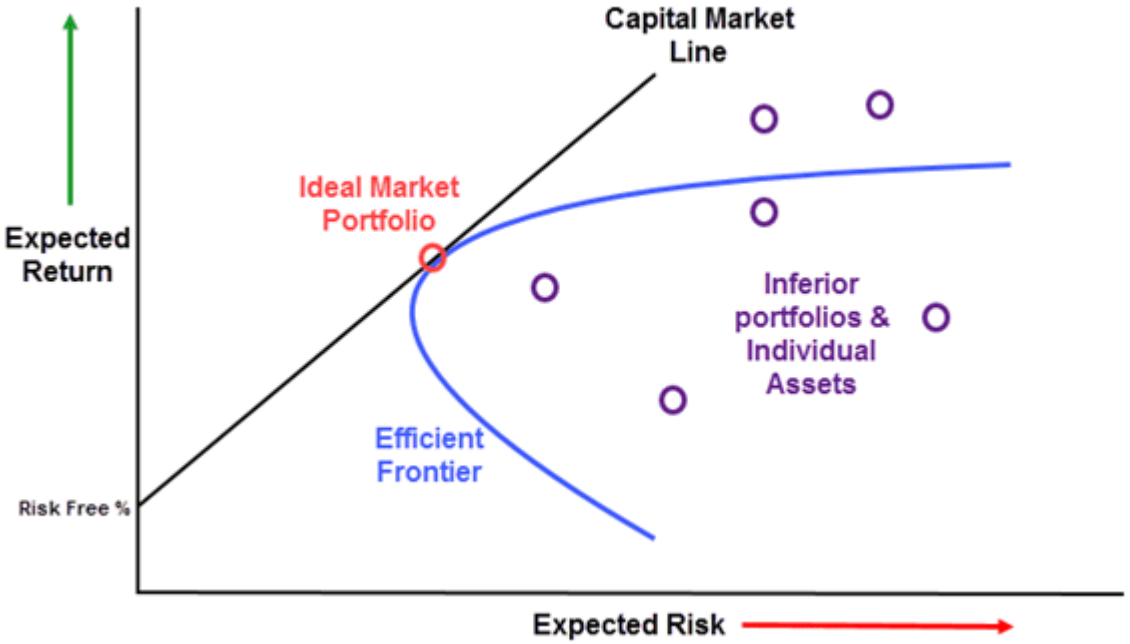

0.09
0.08
0.07
0.06
0.05
0.04
0.01
0
Probability Density
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
Field A alone
Field A by difference
….and what is the right amount of compensation?
A



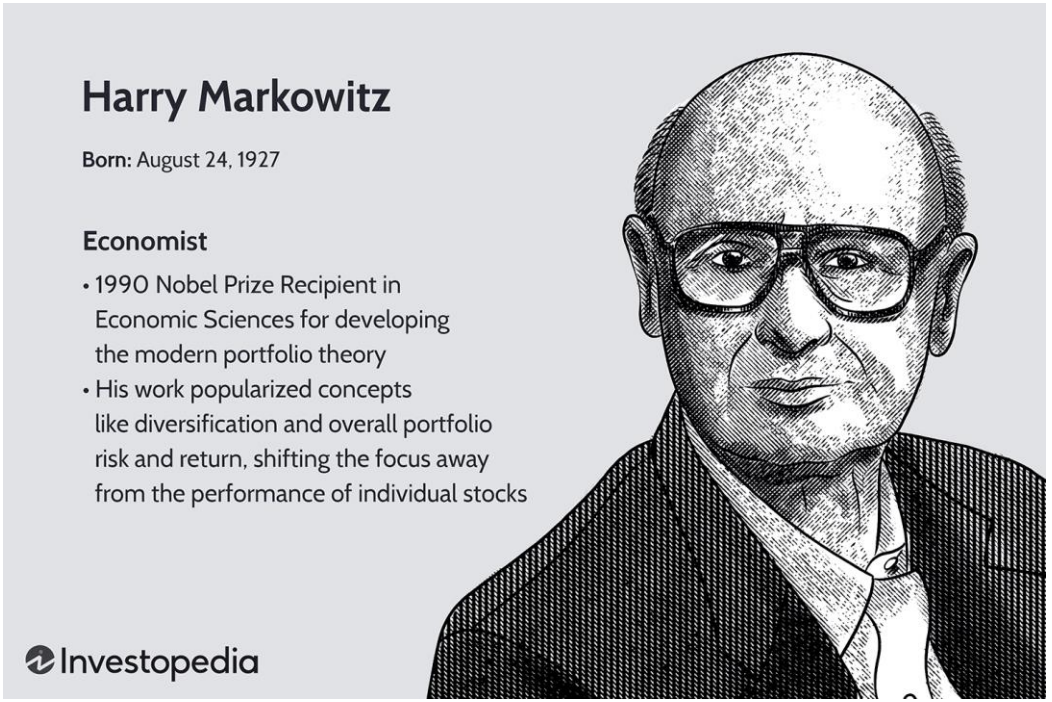
Simple Example

Risk and Return

Modern Portfolio Theory



The MPT assumes that investors are risk-averse, meaning they prefer a less risky portfolio to a riskier one for a given level of return.



Used to calculate discount rates in NPV calculations – Capital Asset Pricing Model (CAPM).

Post Modern Portfolio theory – based on downside risk

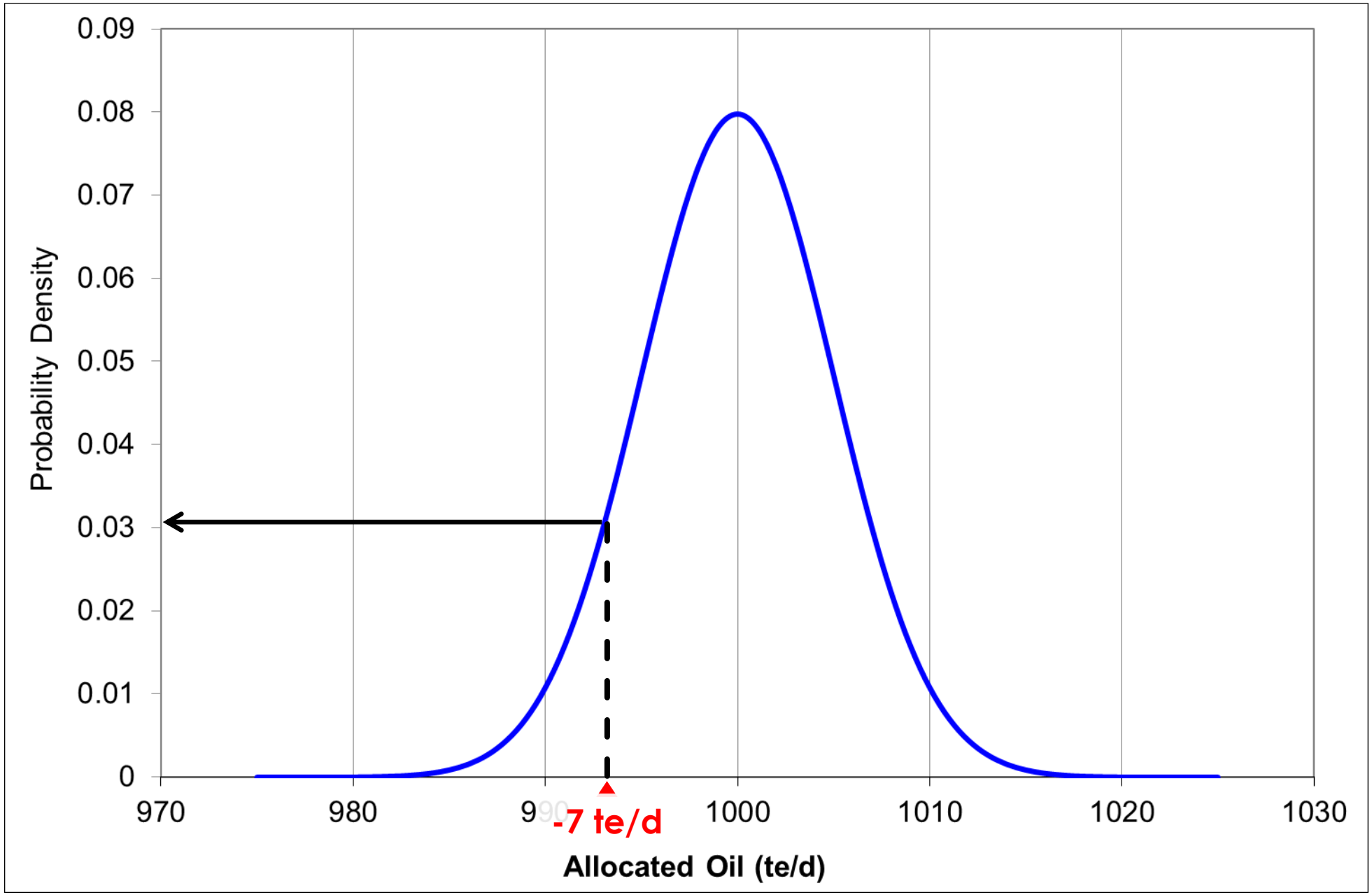
Basis

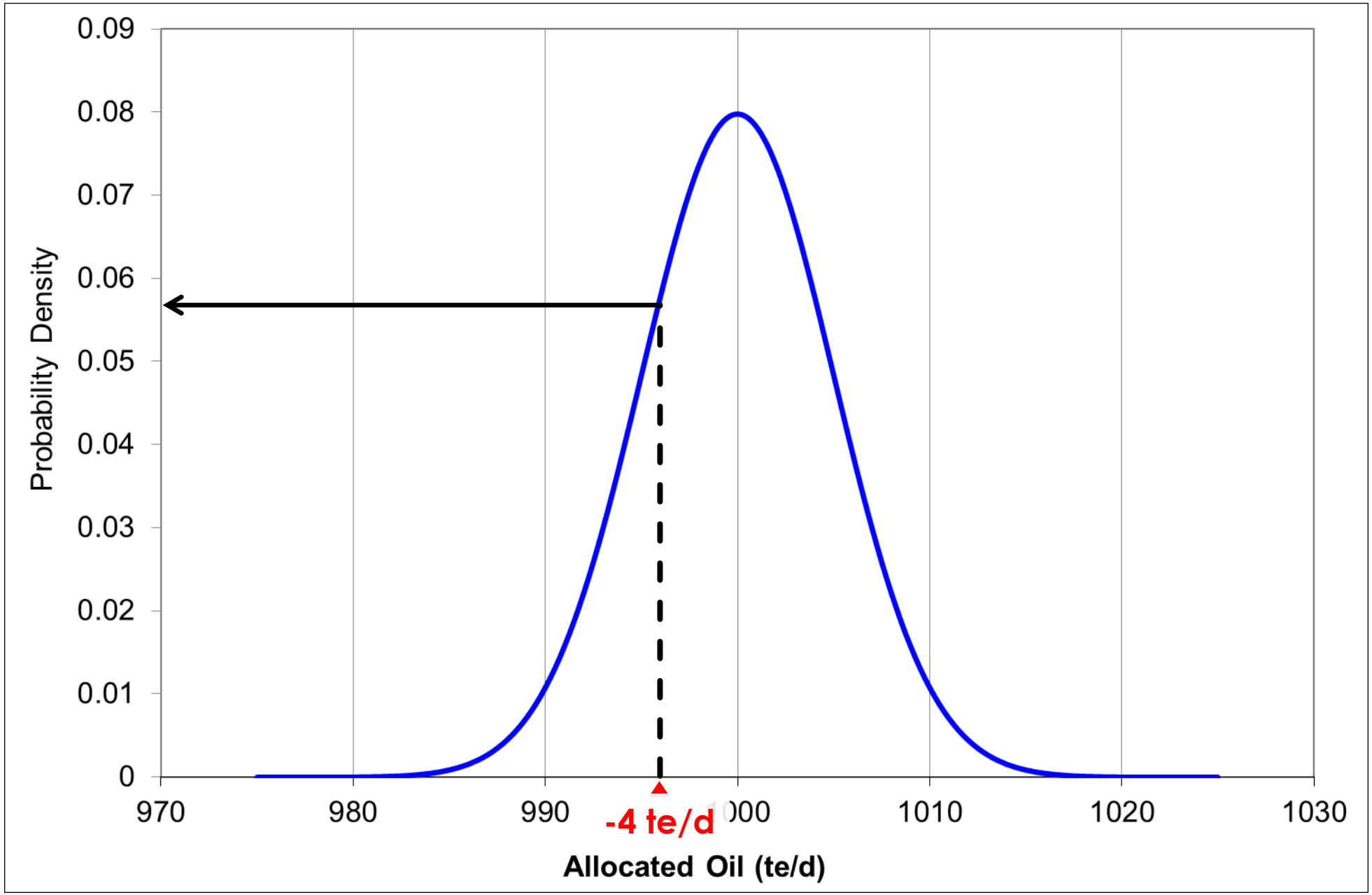
1. Uncertainty described by the Normal or Gaussian distribution
2. Utility
   a) Loss averse
   b) Indifferent to gains

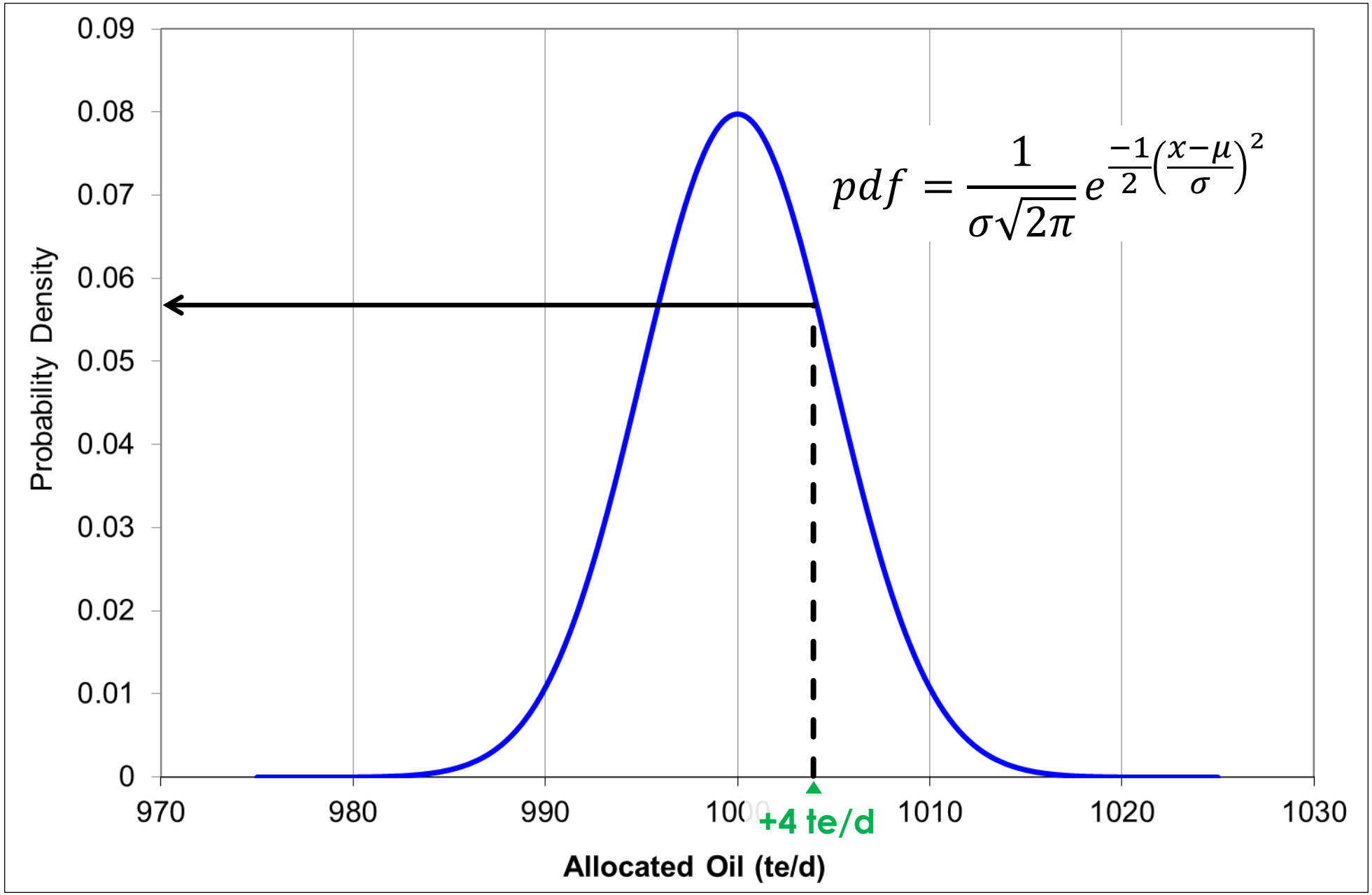
Simple Example

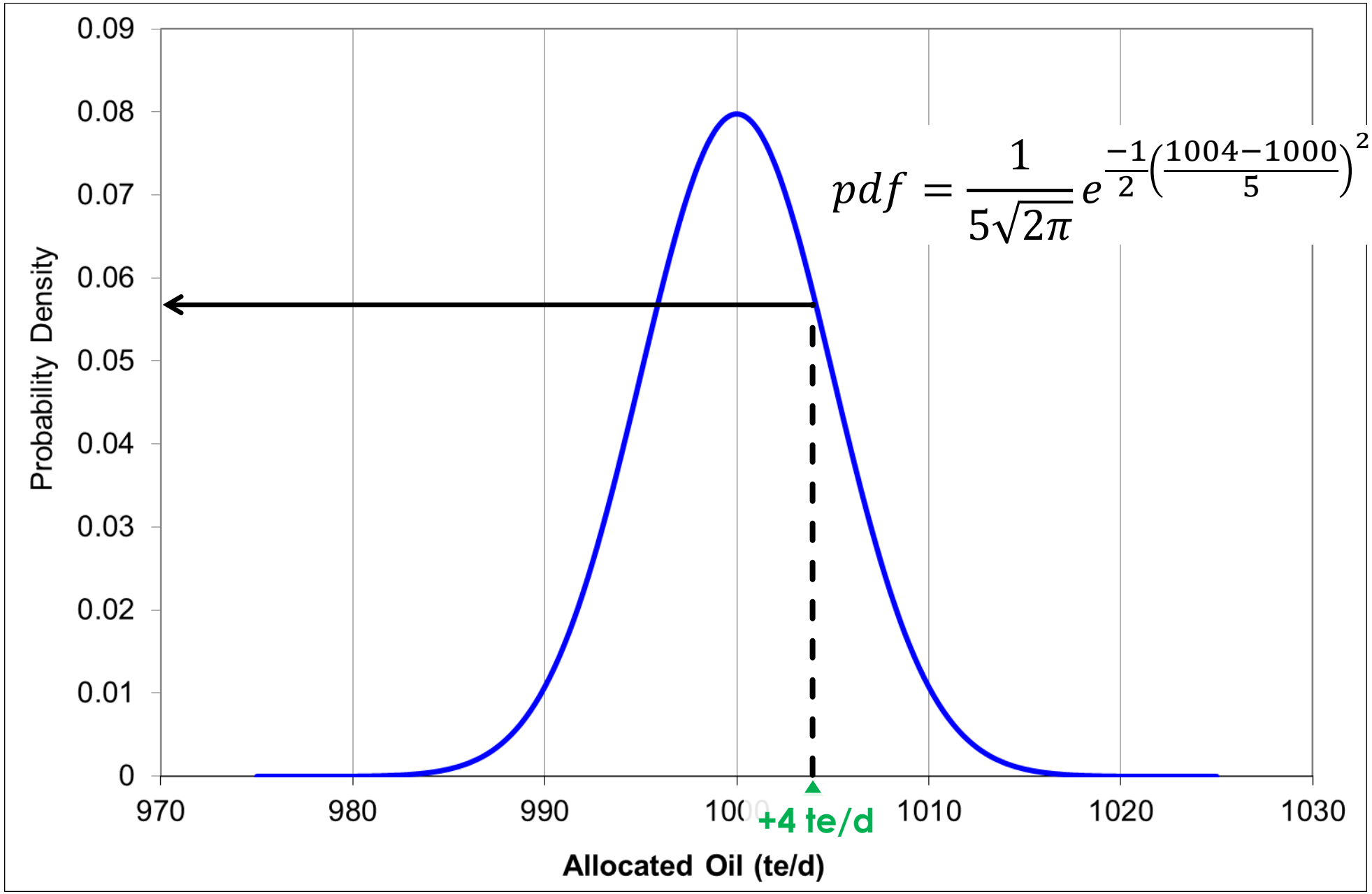
Risk and Return

Uncertainty and the Normal Distribution


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
-7 te/d
Allocated Oil (te/d)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
-4 te/d
1010
1020
1030
Allocated Oil (te/d)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
+4 te/d
Allocated Oil (te/d)
$pdf = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$

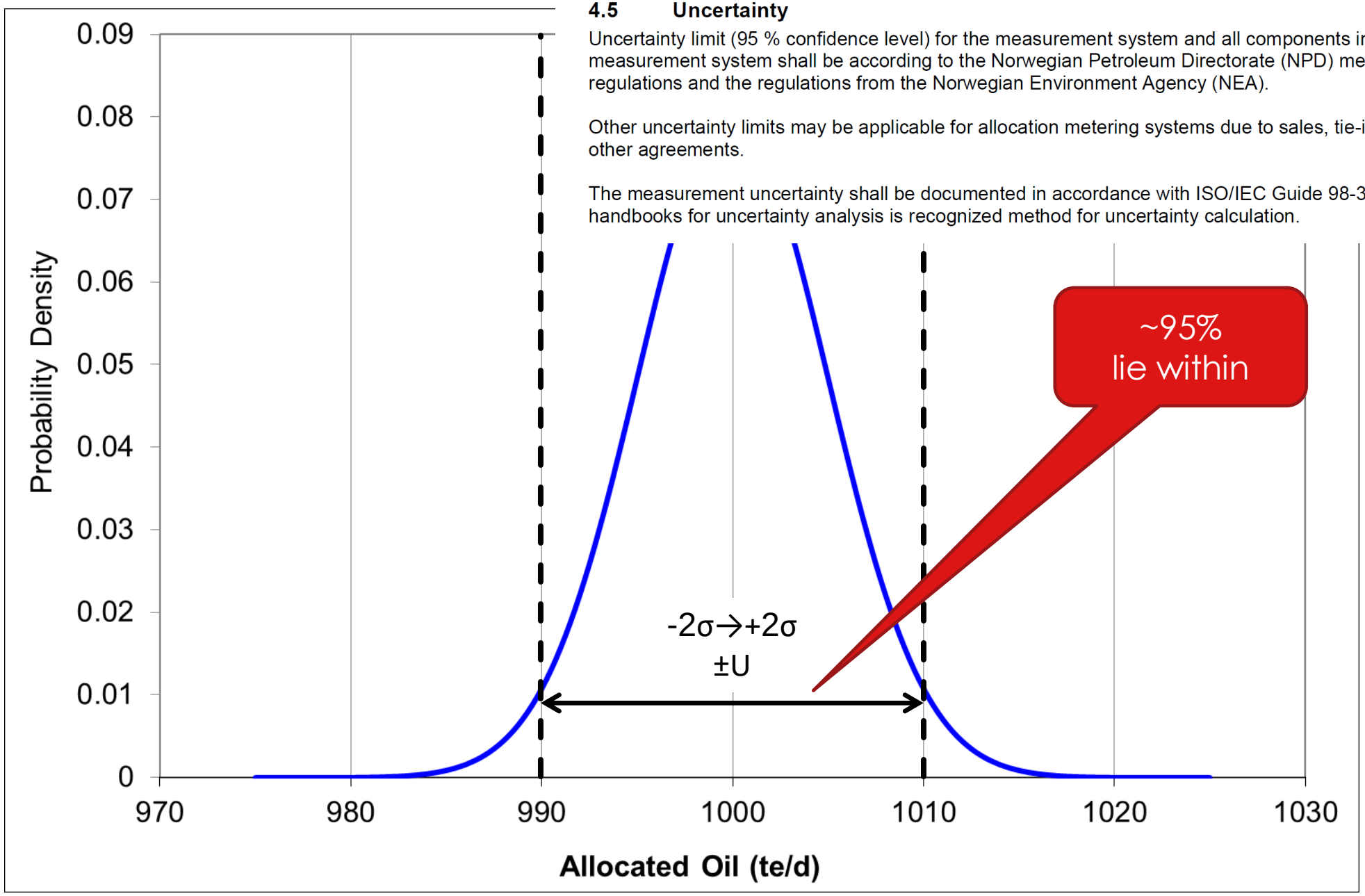

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
+4 te/d
Allocated Oil (te/d)
$pdf = \frac{1}{5\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{1004-1000}{5}\right)^2}$

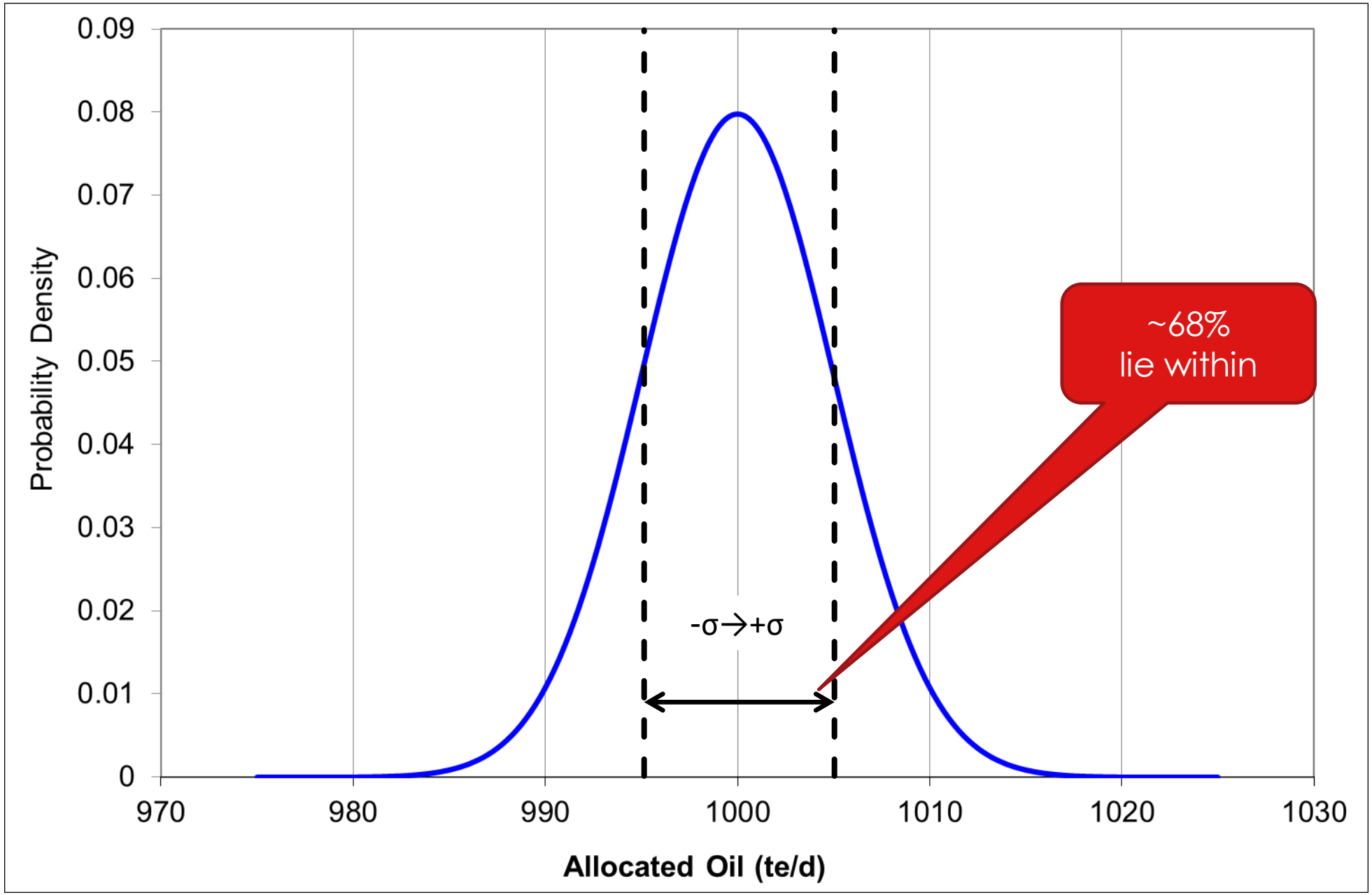
4.5 Uncertainty

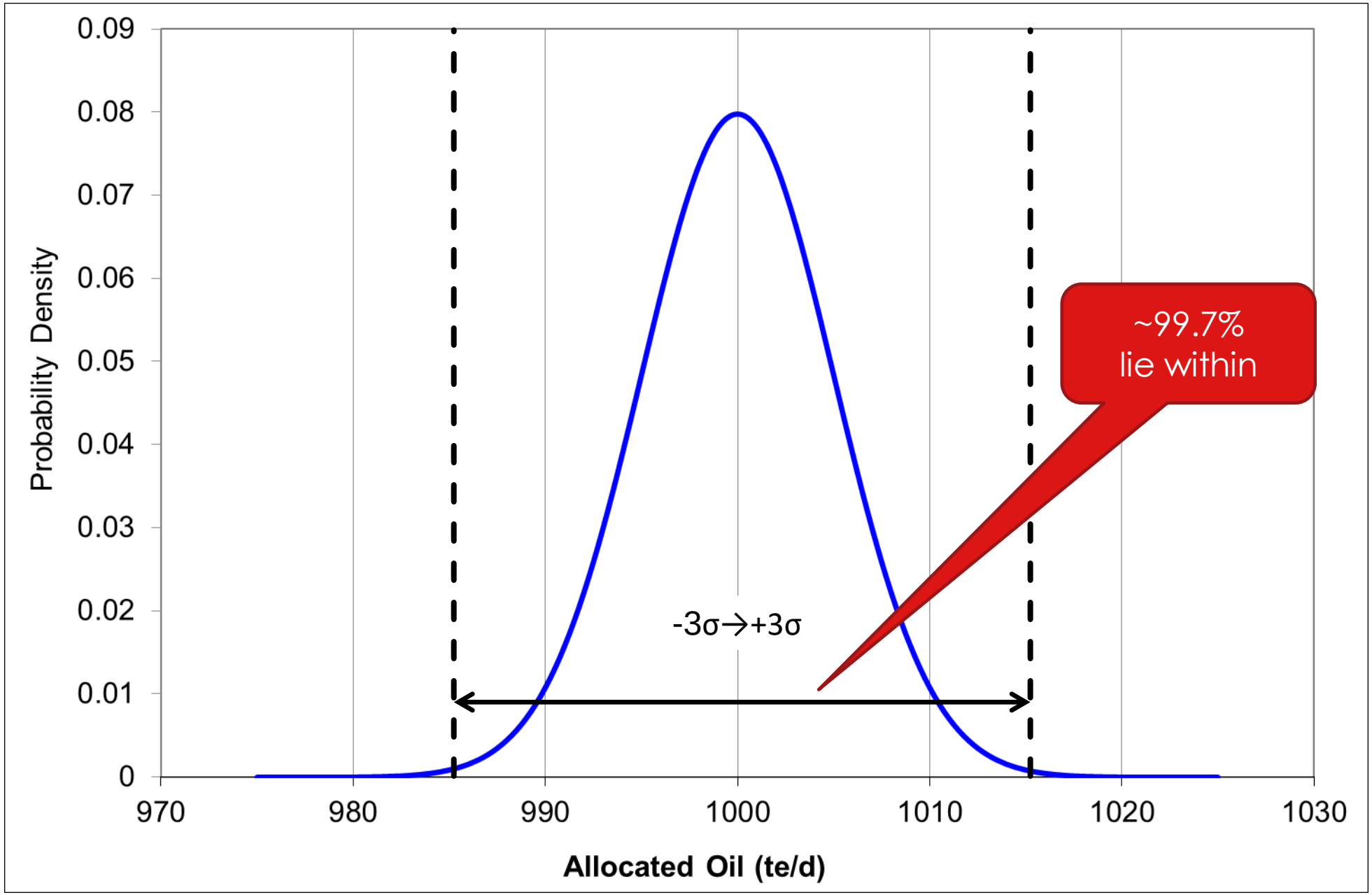
Uncertainty limit (95 % confidence level) for the measurement system and all components in the measurement system shall be according to the Norwegian Petroleum Directorate (NPD) measurement regulations and the regulations from the Norwegian Environment Agency (NEA).

Other uncertainty limits may be applicable for allocation metering systems due to sales, tie-in, processing or other agreements.

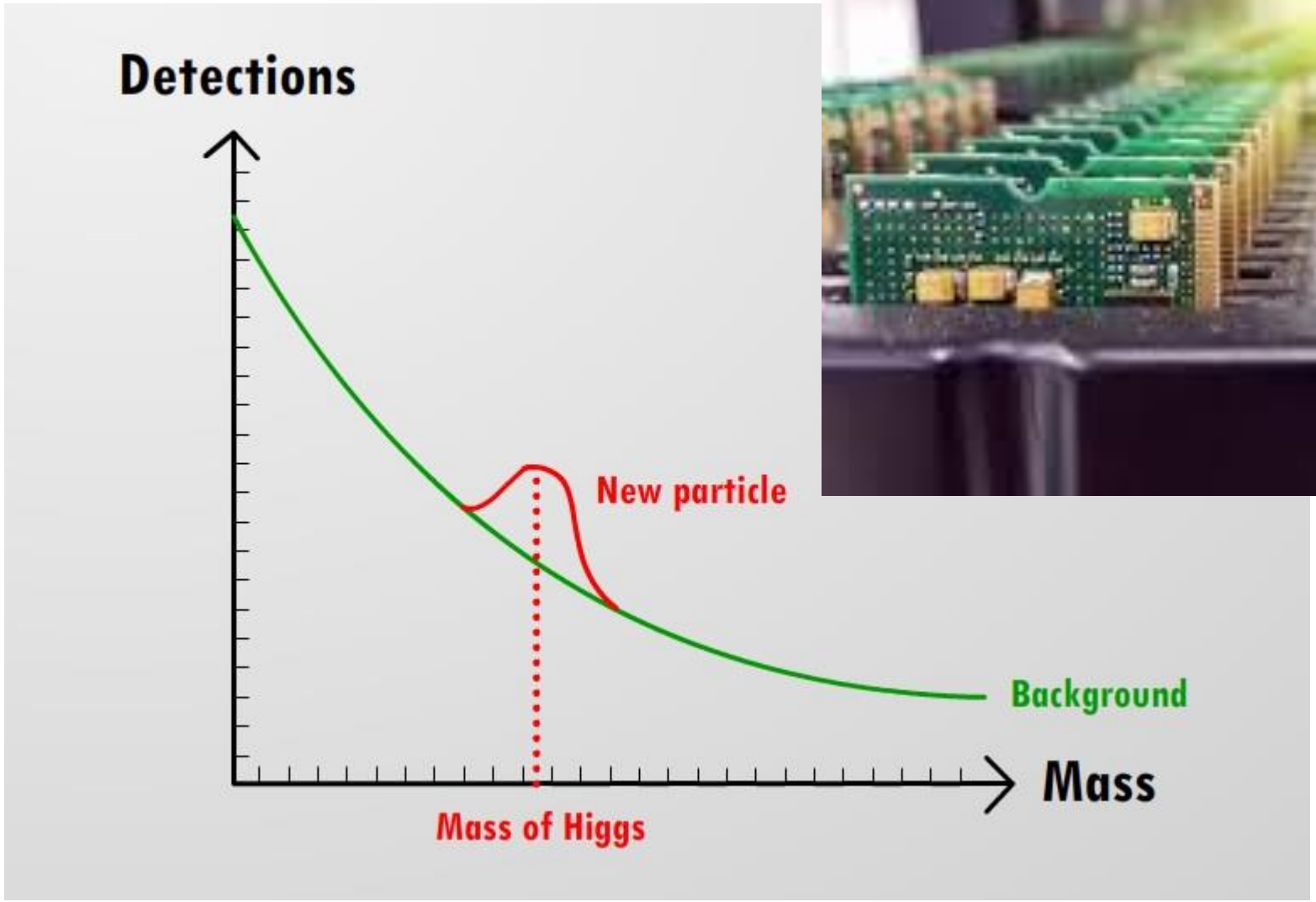
The measurement uncertainty shall be documented in accordance with ISO/IEC Guide 98-3:2008. NFOGM handbooks for uncertainty analysis is recognized method for uncertainty calculation.



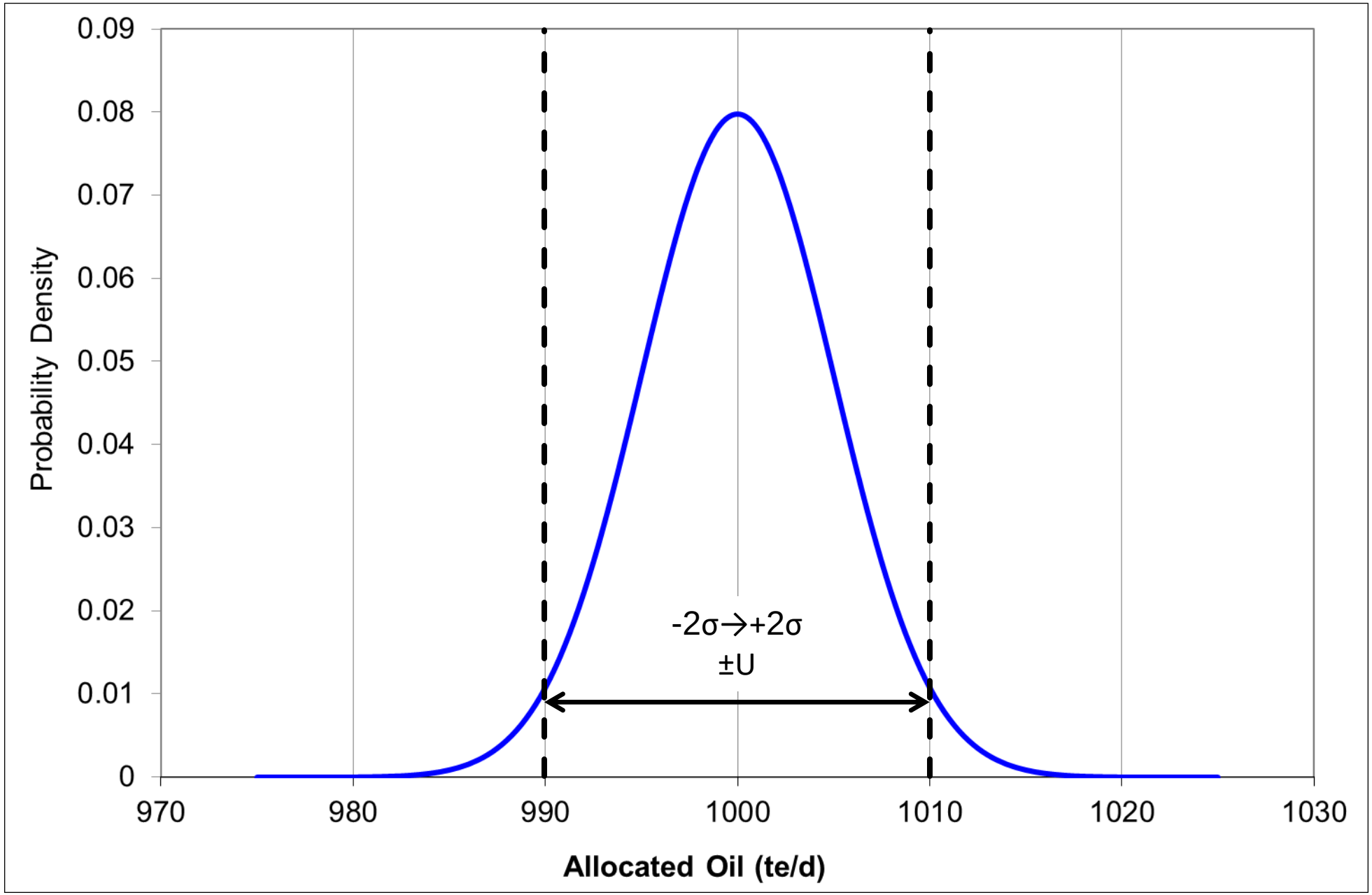

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)
-σ→+σ
~68%
lie within

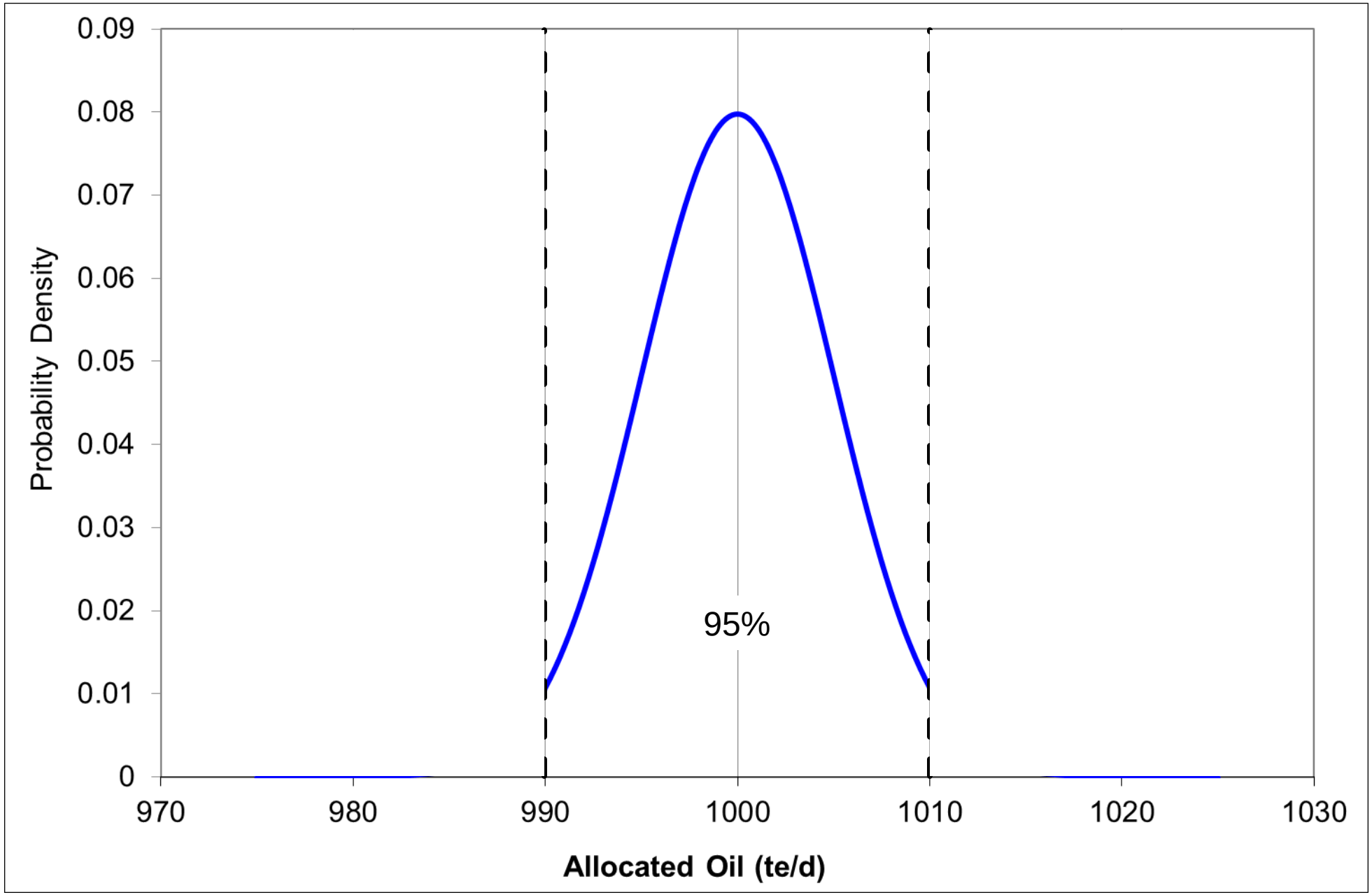

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)
-3σ→+3σ
~99.7%
lie within

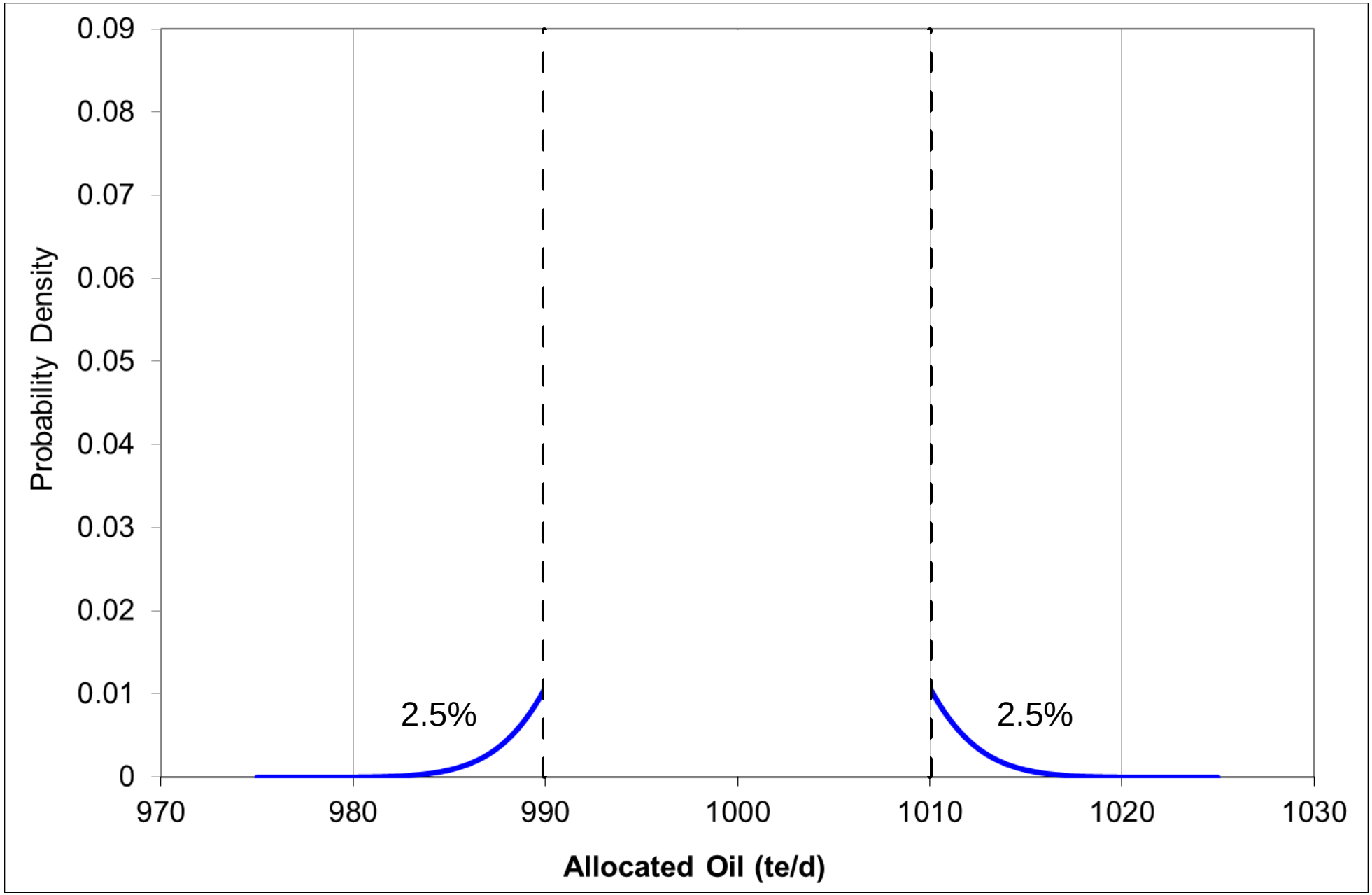
5σ

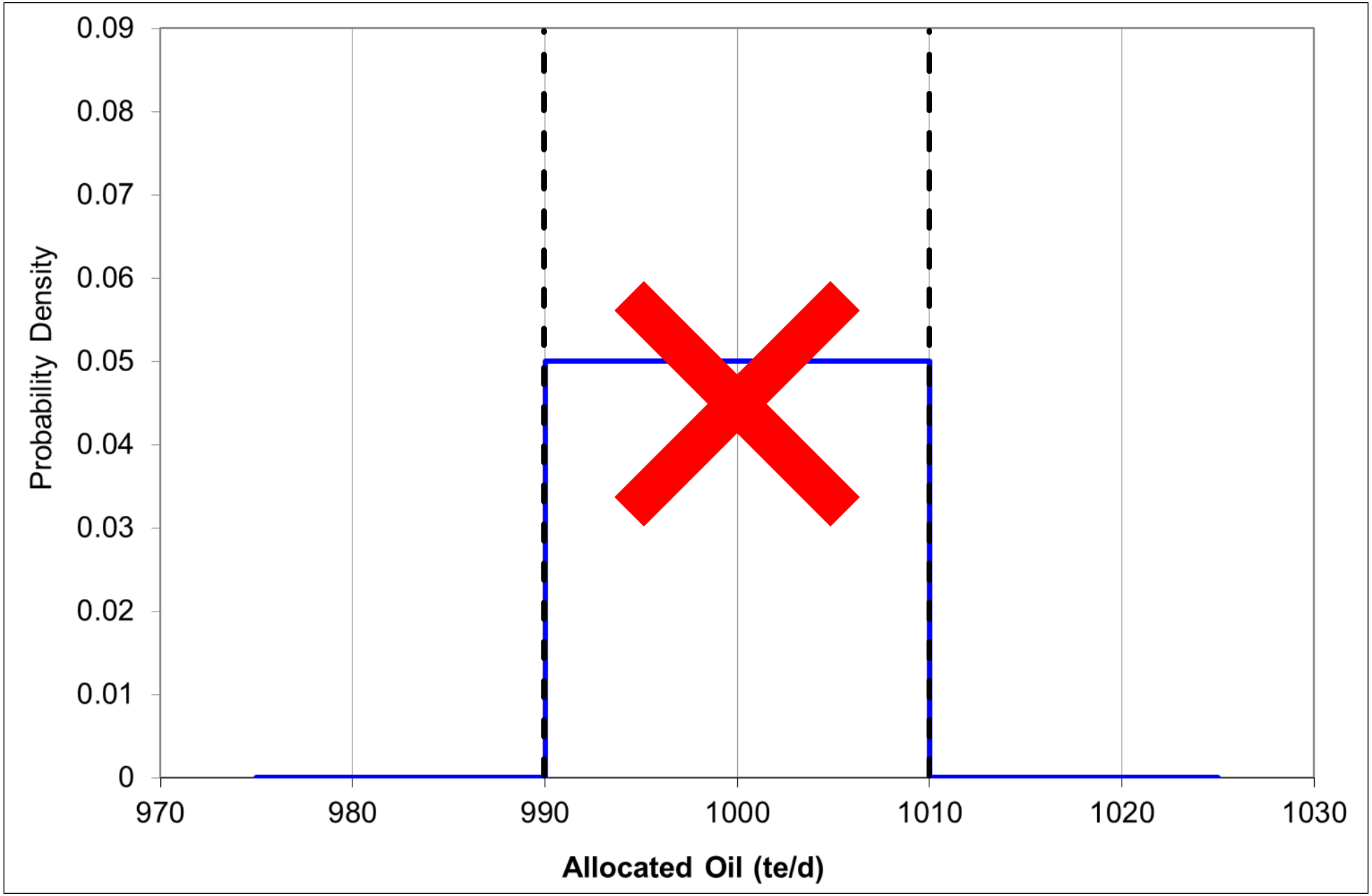


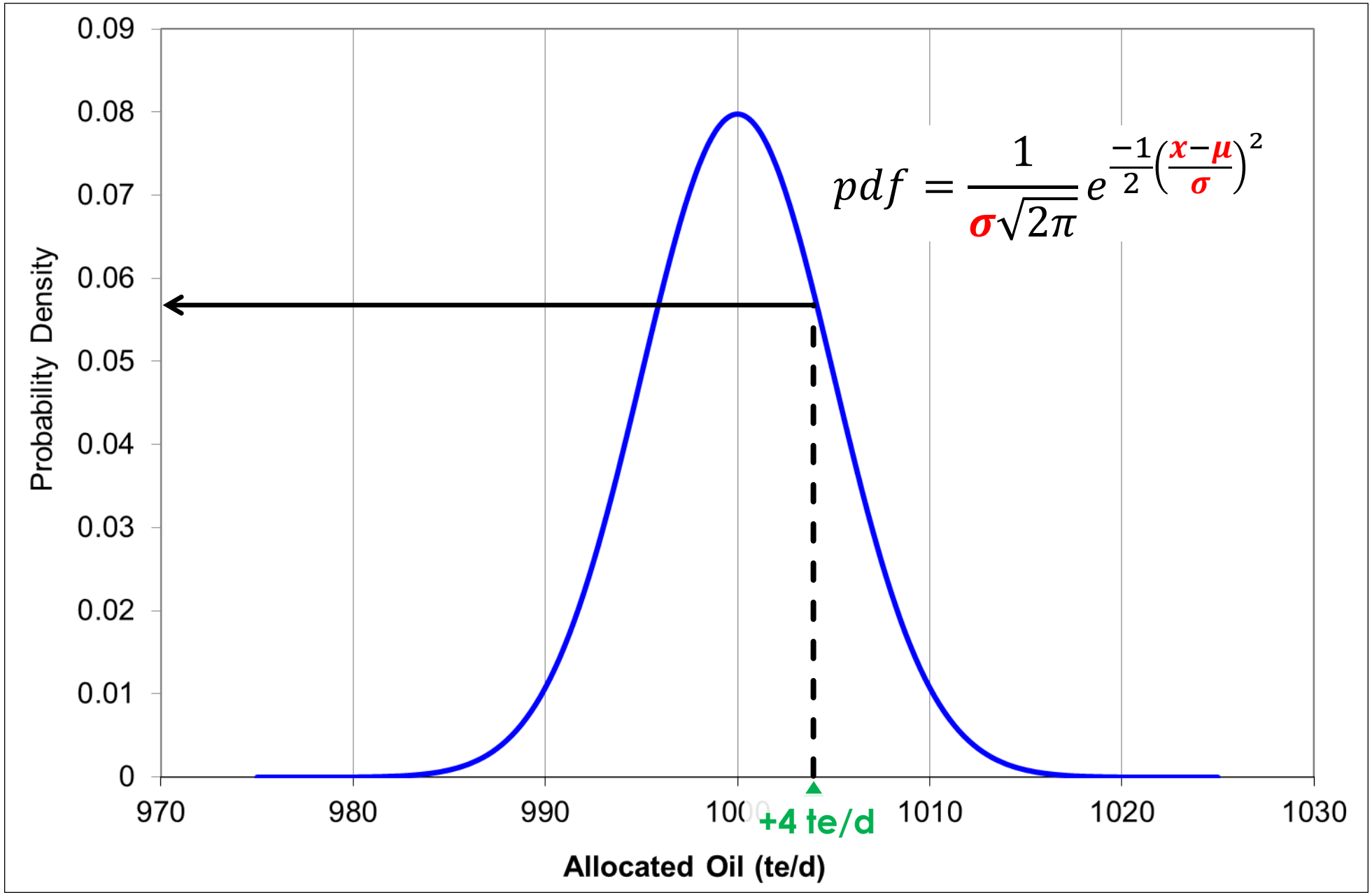
6σ


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)
-2σ→+2σ
±U


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
95%
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
2.5%
2.5%
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
Allocated Oil (te/d)


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
980
990
1000
1010
1020
1030
+4 te/d
Allocated Oil (te/d)
$pdf = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$

From predicting the orbit of Ceres…

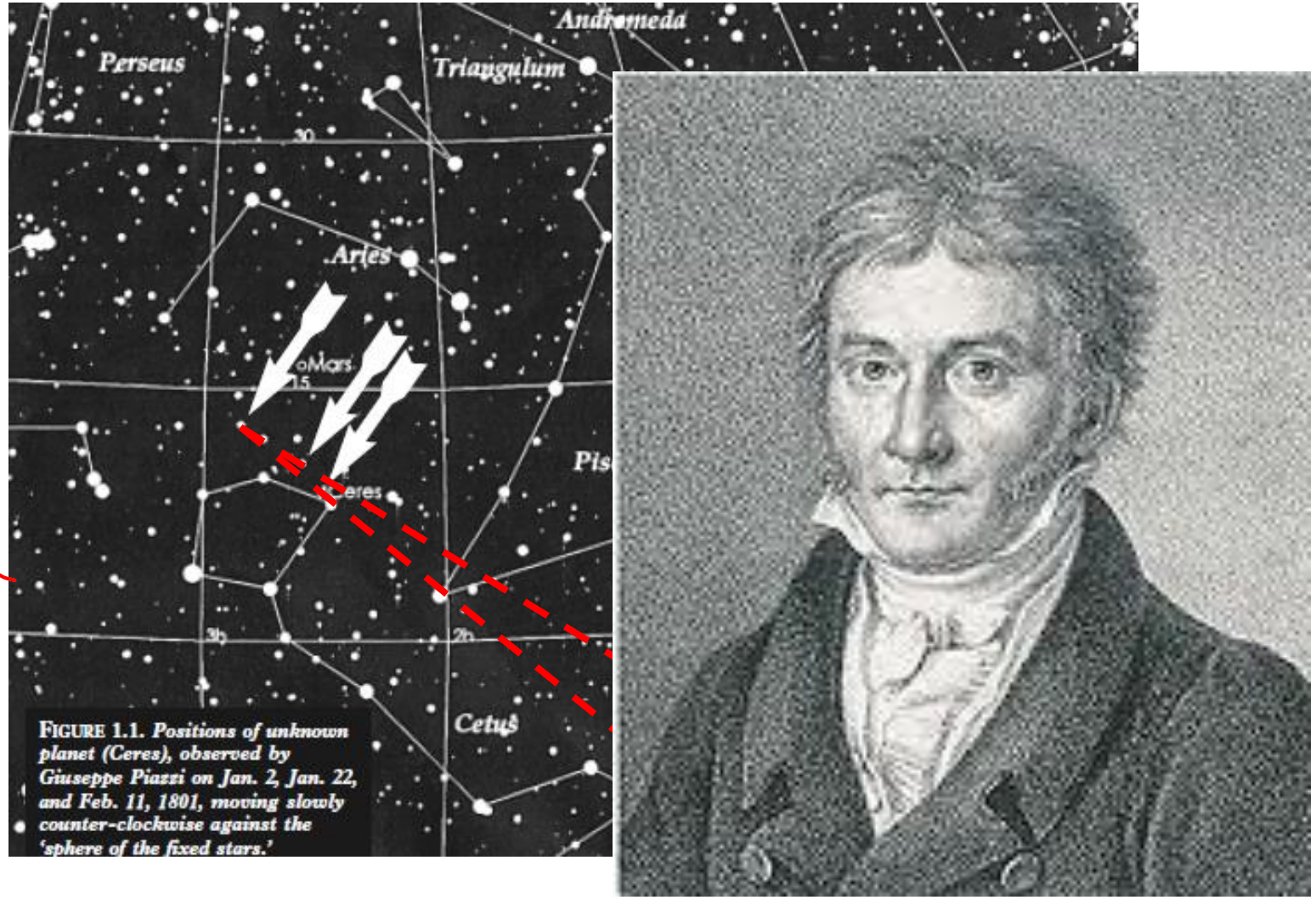
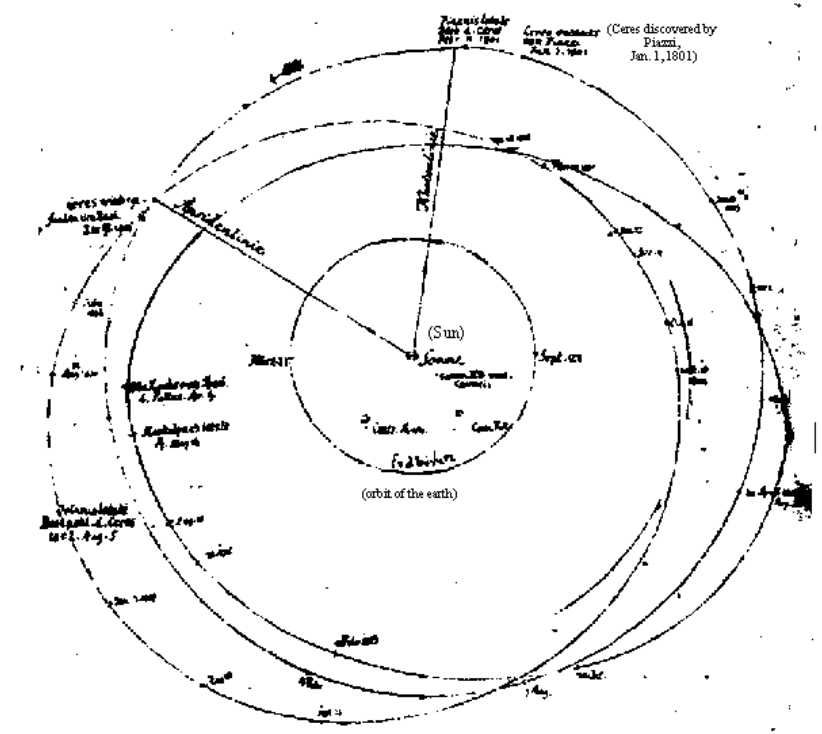
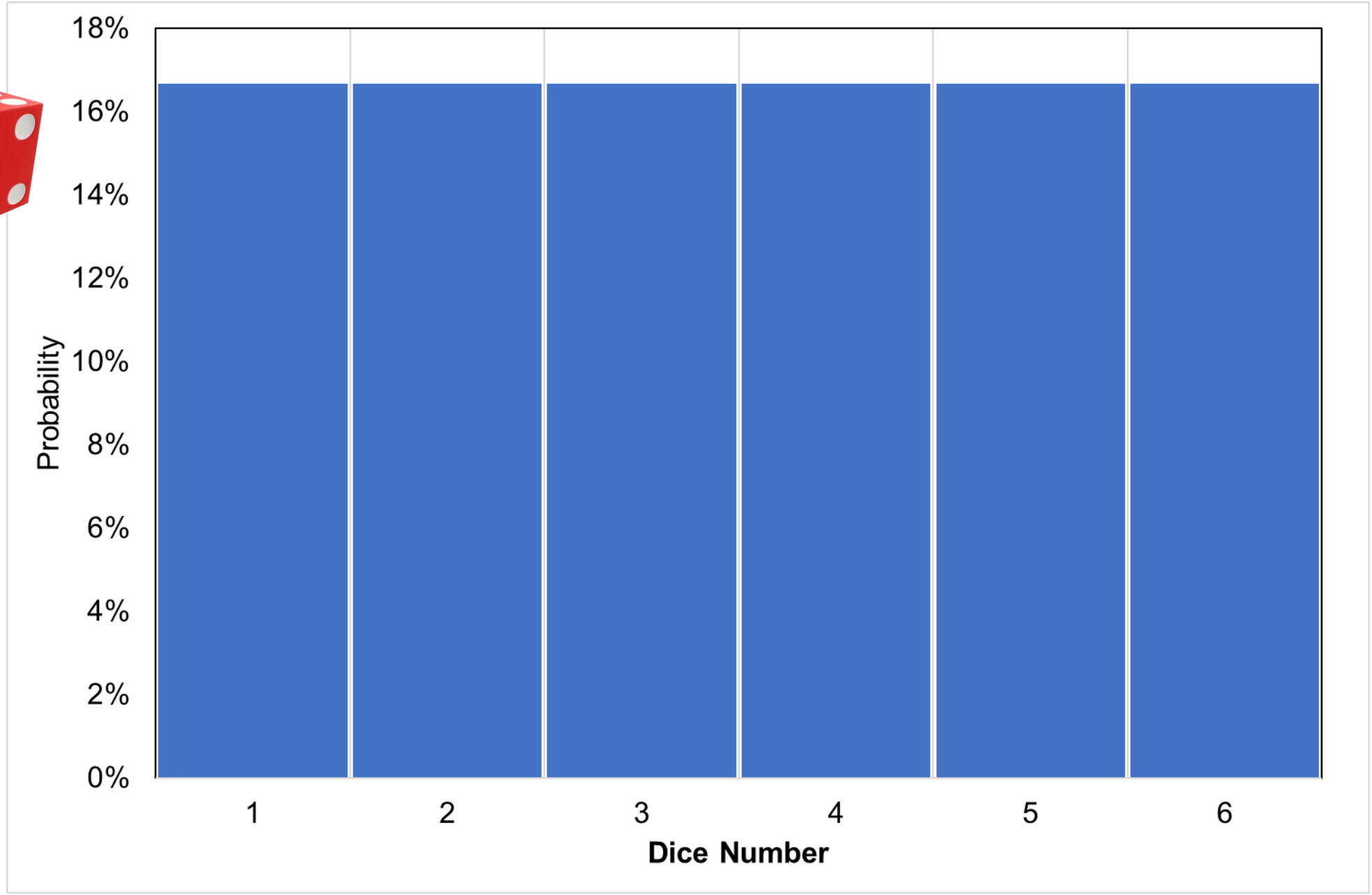


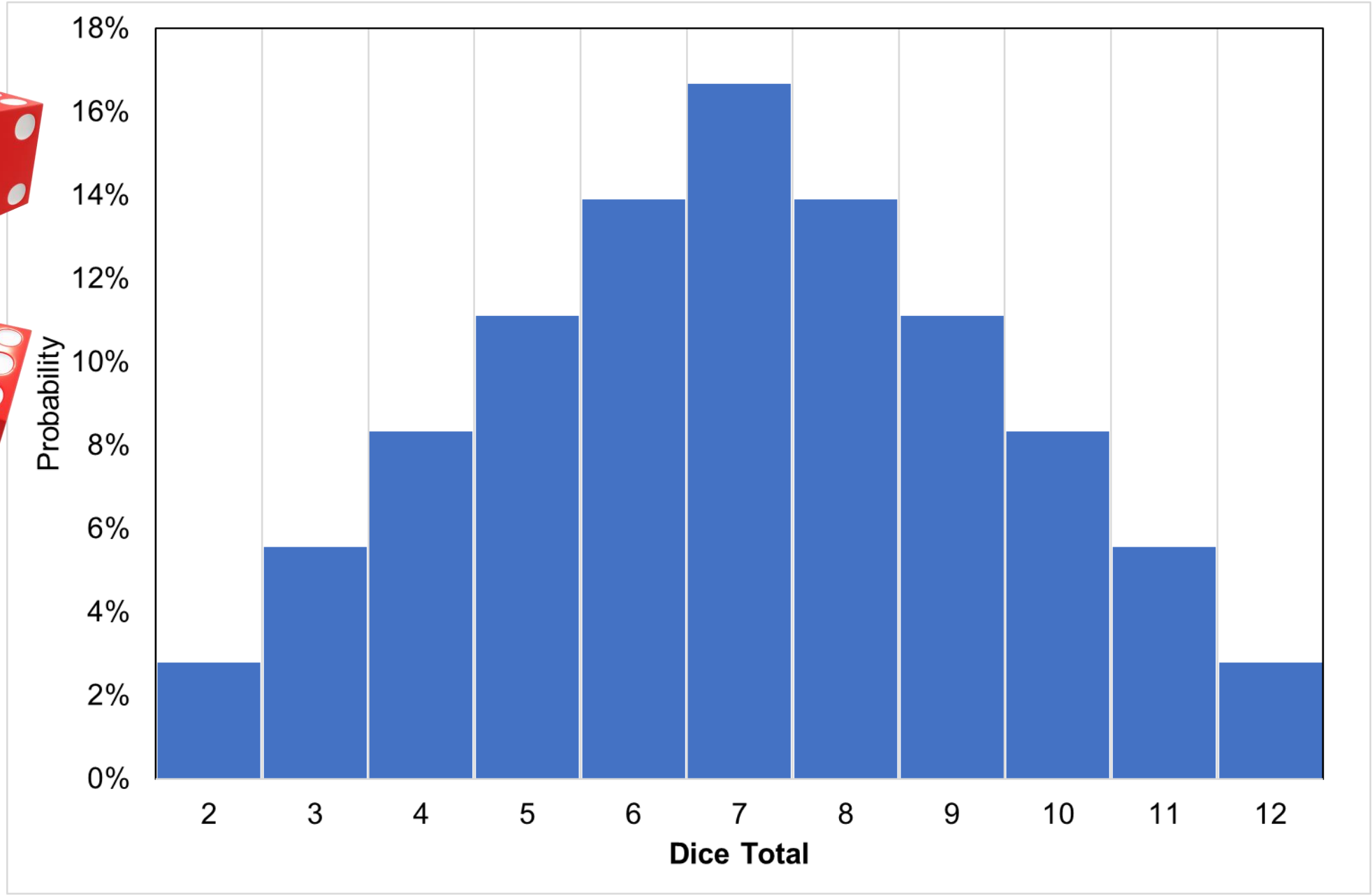
FIGURE 1.1. *Positions of unknown planet (Ceres), observed by Giuseppe Piazzi on Jan. 2, Jan. 22, and Feb. 11, 1801, moving slowly counter-clockwise against the 'sphere of the fixed stars.'*

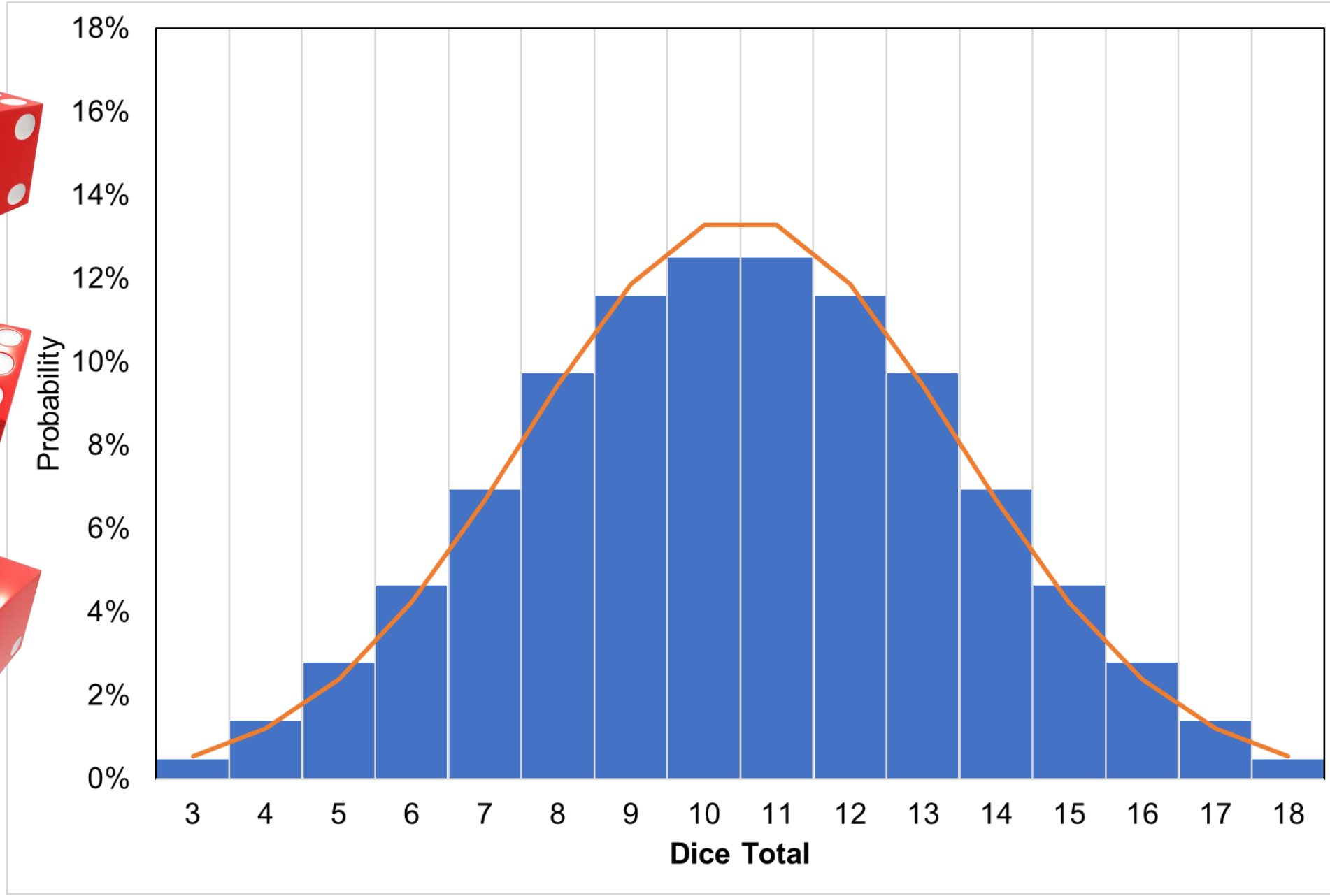
Gauss Develops the Mathematics of Uncertainty



Sketch of the orbits of Ceres and Pallas (nachlaß Gauß, Handb. 4). Courtesy of Universitätsbibliothek Göttingen.

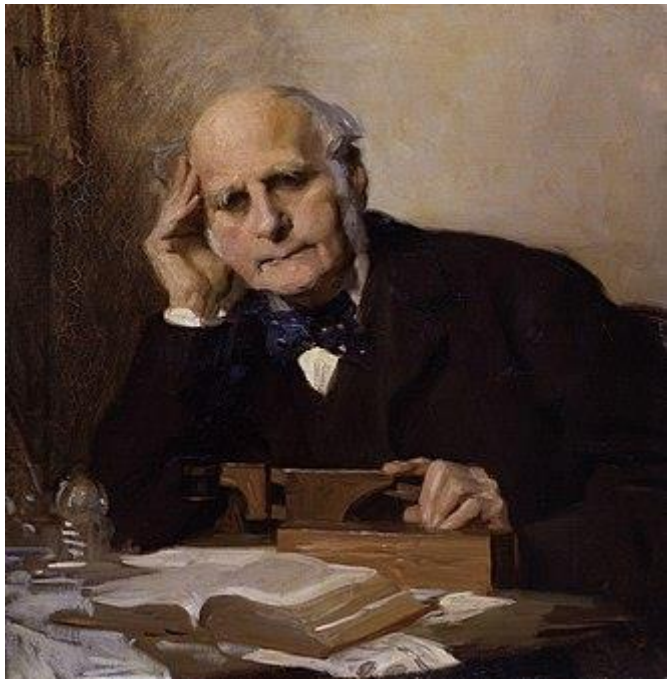

18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Probability
1
2
3
4
5
6
Dice Number


18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Probability
2
3
4
5
6
7
8
9
10
11
12
Dice Total


18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Probability
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Dice Total

Central Limit Theorem

"I know of scarcely anything so apt to impress the imagination as the wonderful form of cosmic order expressed by the [Central Limit Theorem]. The law would have been personified by the Greeks and deified, if they had known of it."



Sir Francis Galton

Simple Example

Risk and Return

Uncertainty and the Normal Distribution

Risk and Loss Aversion

Offered a Gamble

Expected Value

50% chance

100% chance

50% chance

Expected value = 0.5*0 +0.5*2 = 1 €

Utility

50% chance

1000000 €
100% chance

50% chance

Expected value = 0.5*0 +0.5*2000000 = 1000000 €

Utility

50% chance

900000 €
100% chance

50% chance

Expected value = 0.5*0 +0.5*2000000 = 1000000 €

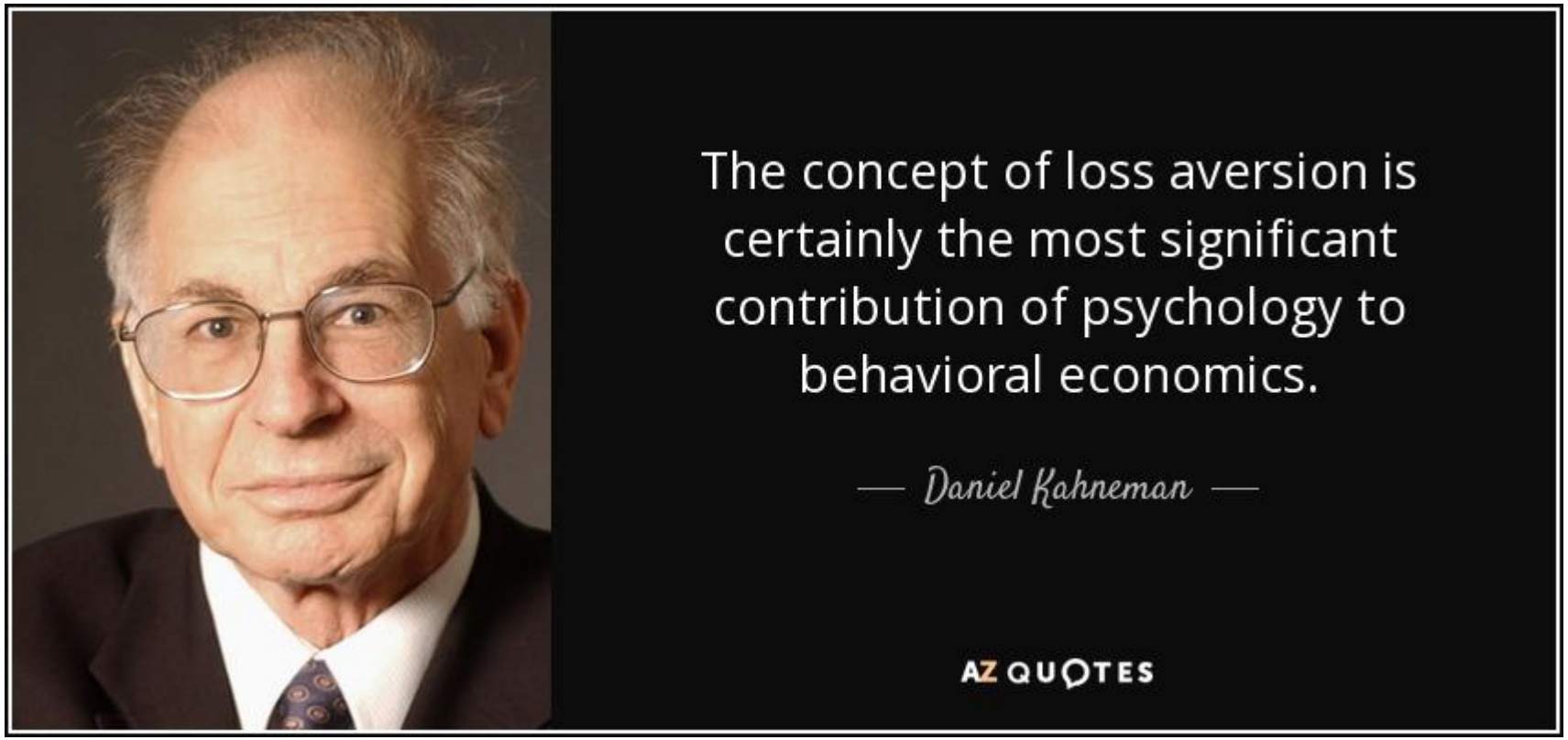
Expected Utility

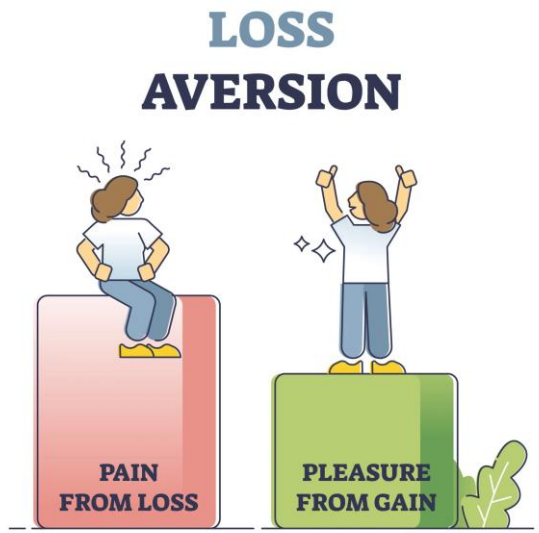
Daniel Bernoulli

St Petersburg Paradox
1713

Nicholas Bernoulli

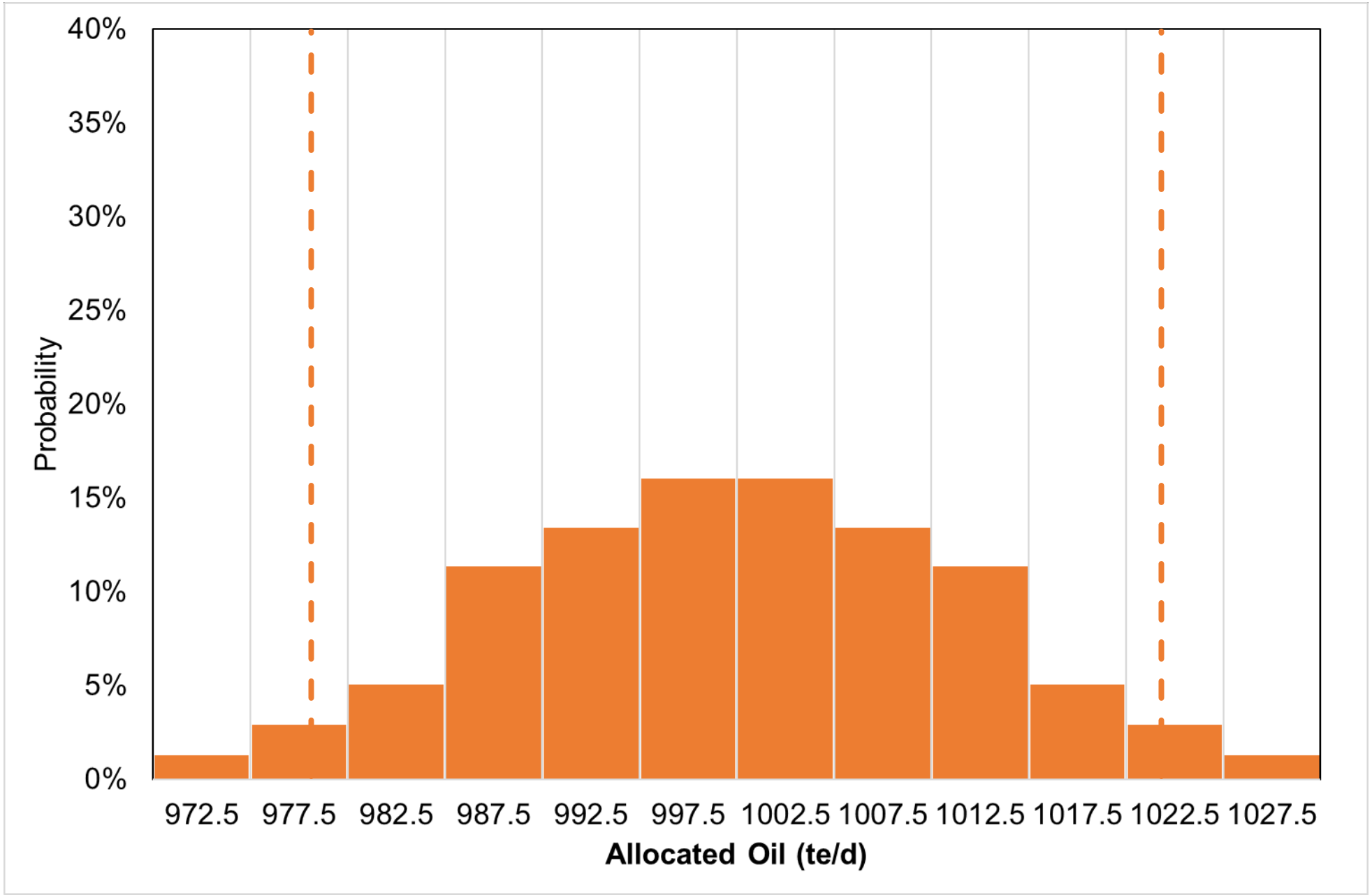
Prospect Theory - Loss Aversion

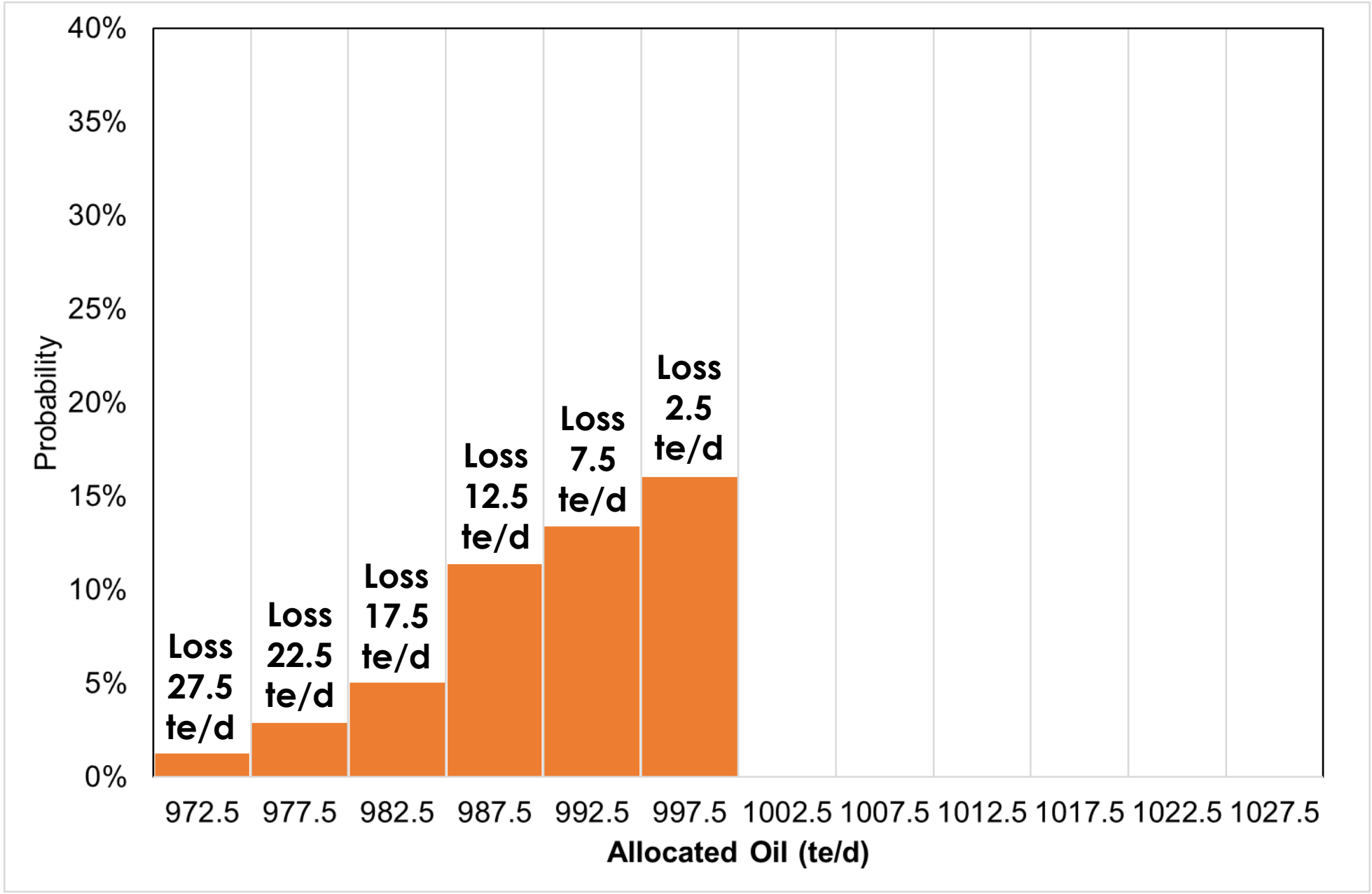


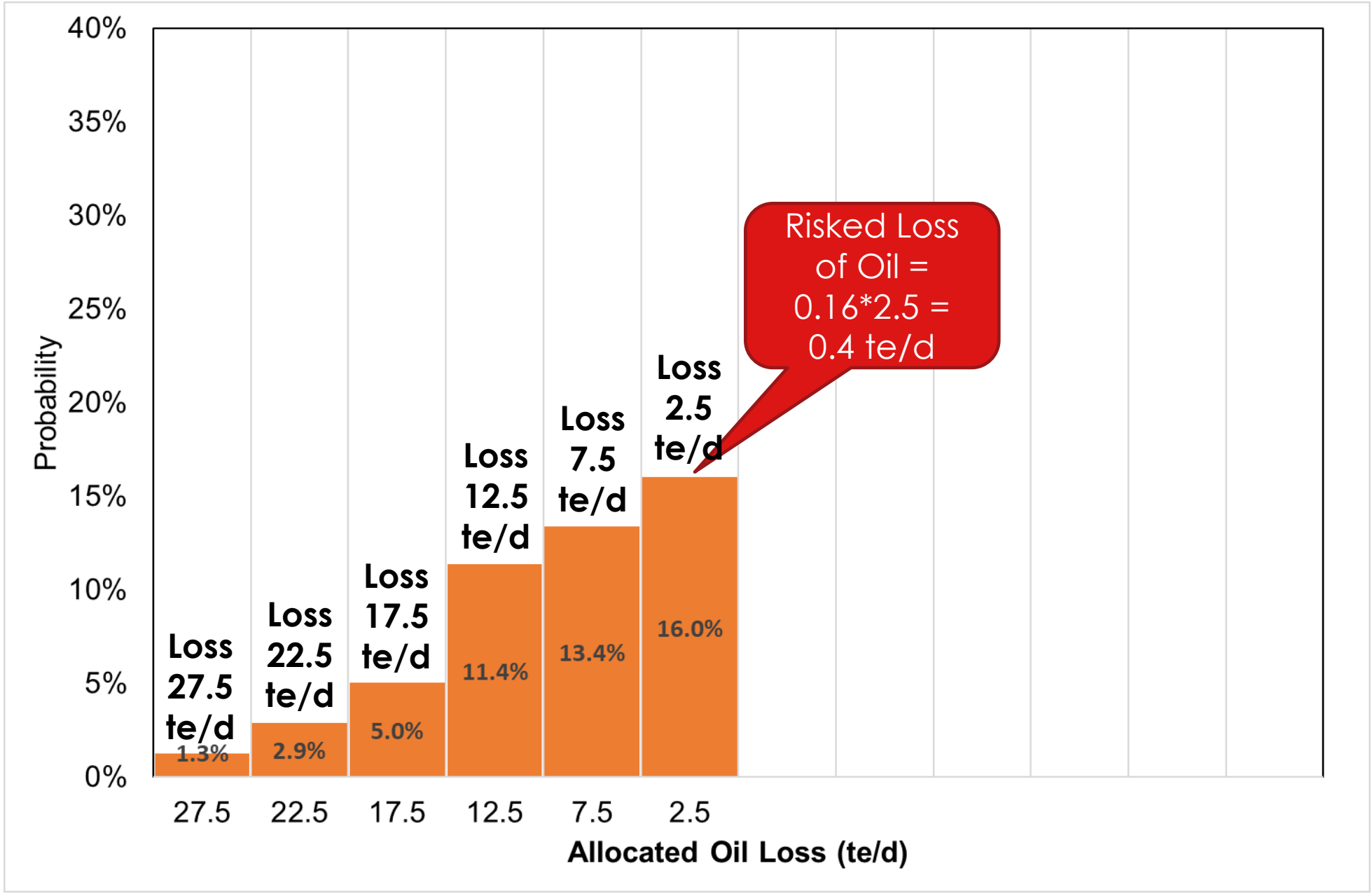


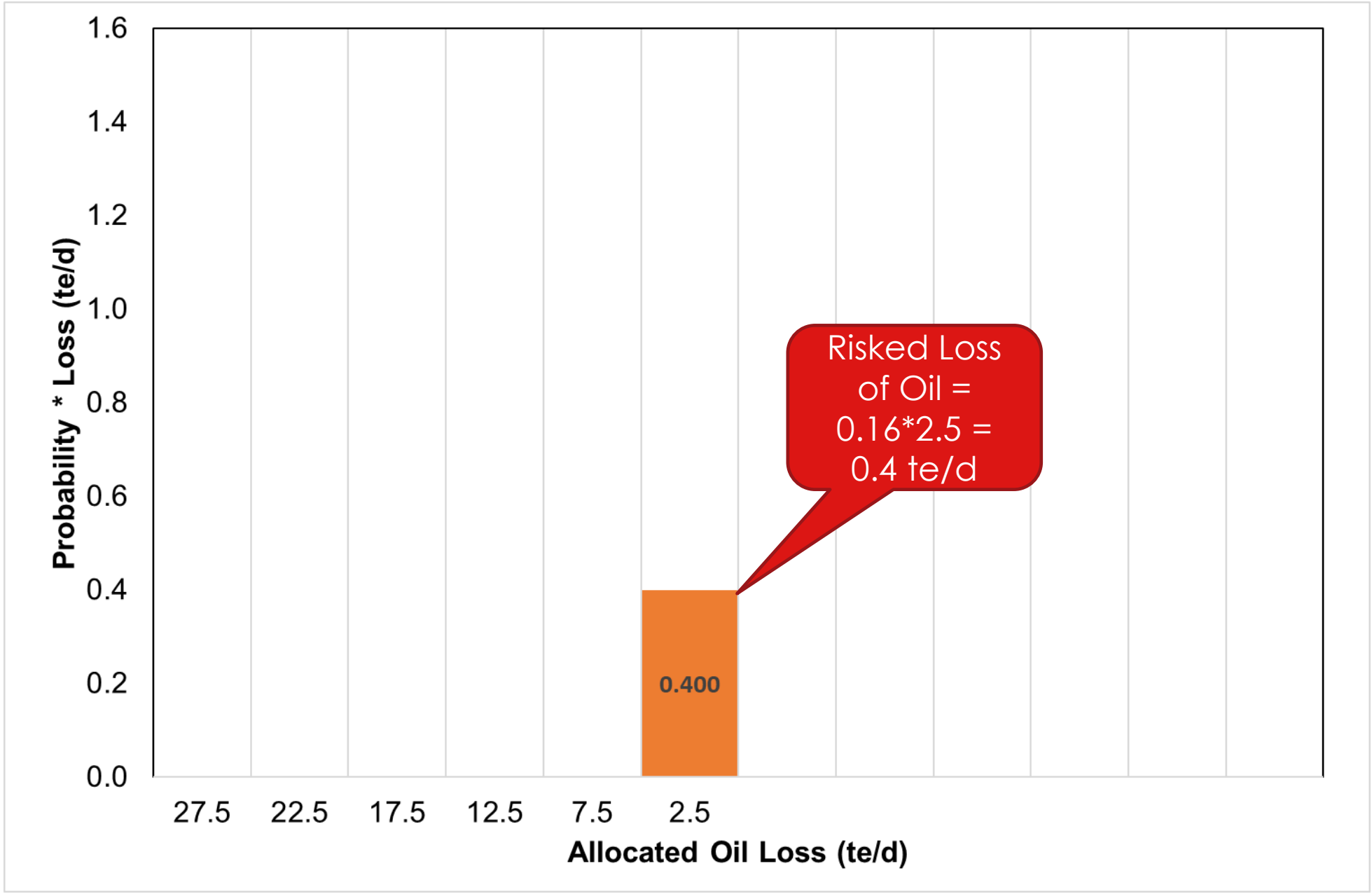
Pain of loss ~ twice joy of gain

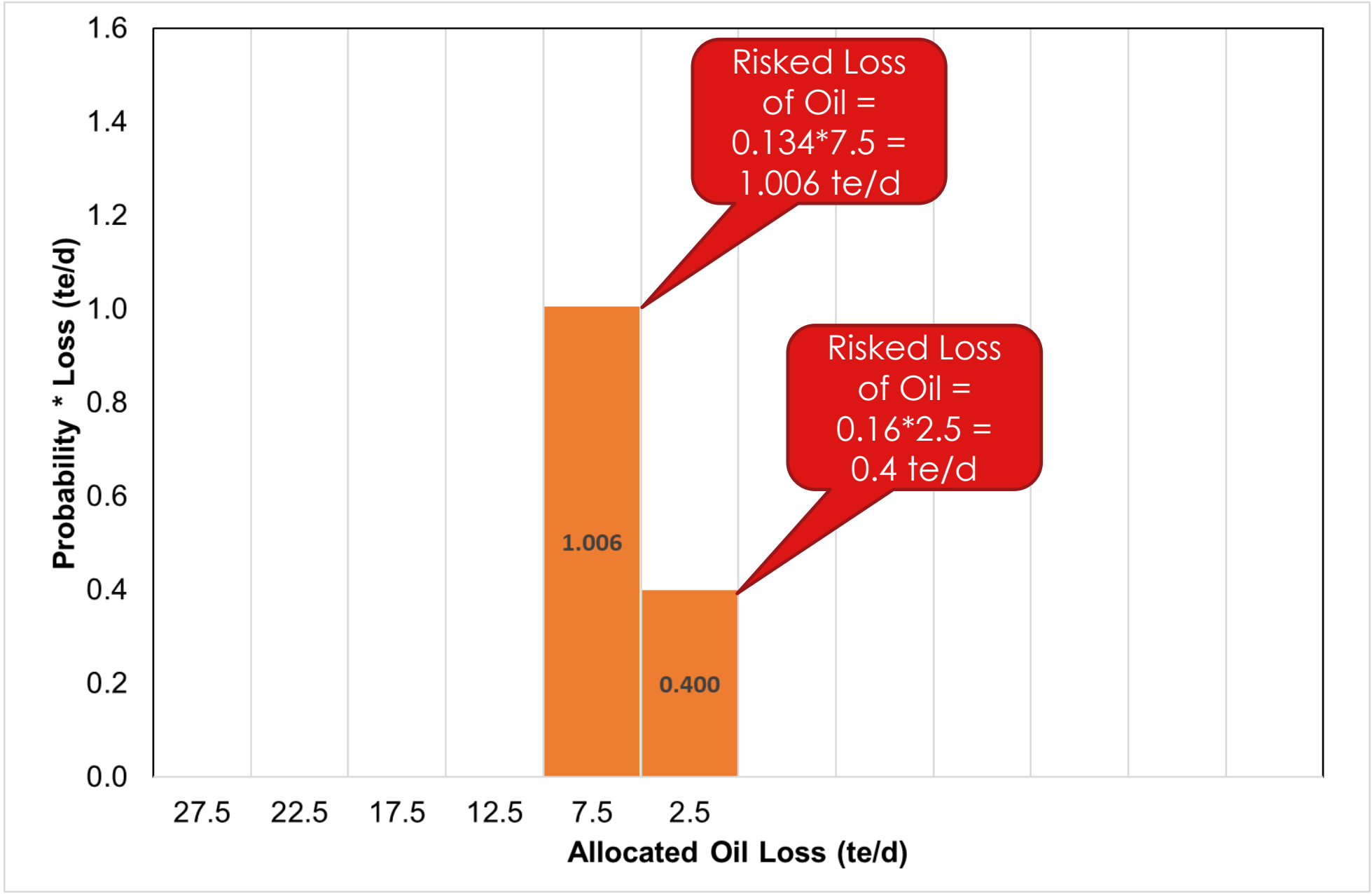
- Simple Example
- Risk and Return
- Uncertainty and the Normal Distribution
- Risk and Loss Aversion
- Integrated Risk of Loss

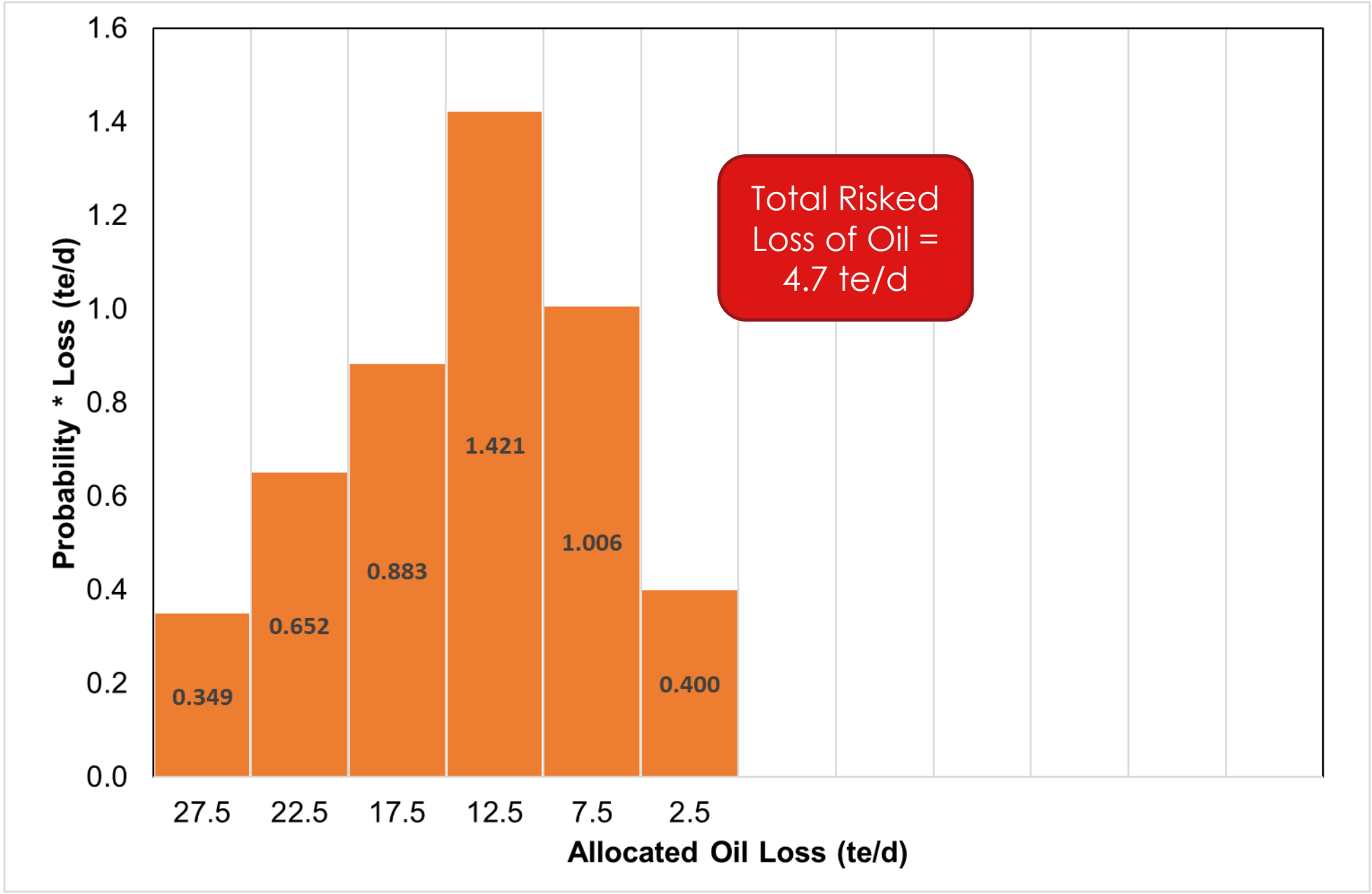

40%
35%
30%
25%
20%
15%
10%
5%
0%
Probability
972.5
977.5
982.5
987.5
992.5
997.5
1002.5
1007.5
1012.5
1017.5
1022.5
1027.5
Allocated Oil (te/d)

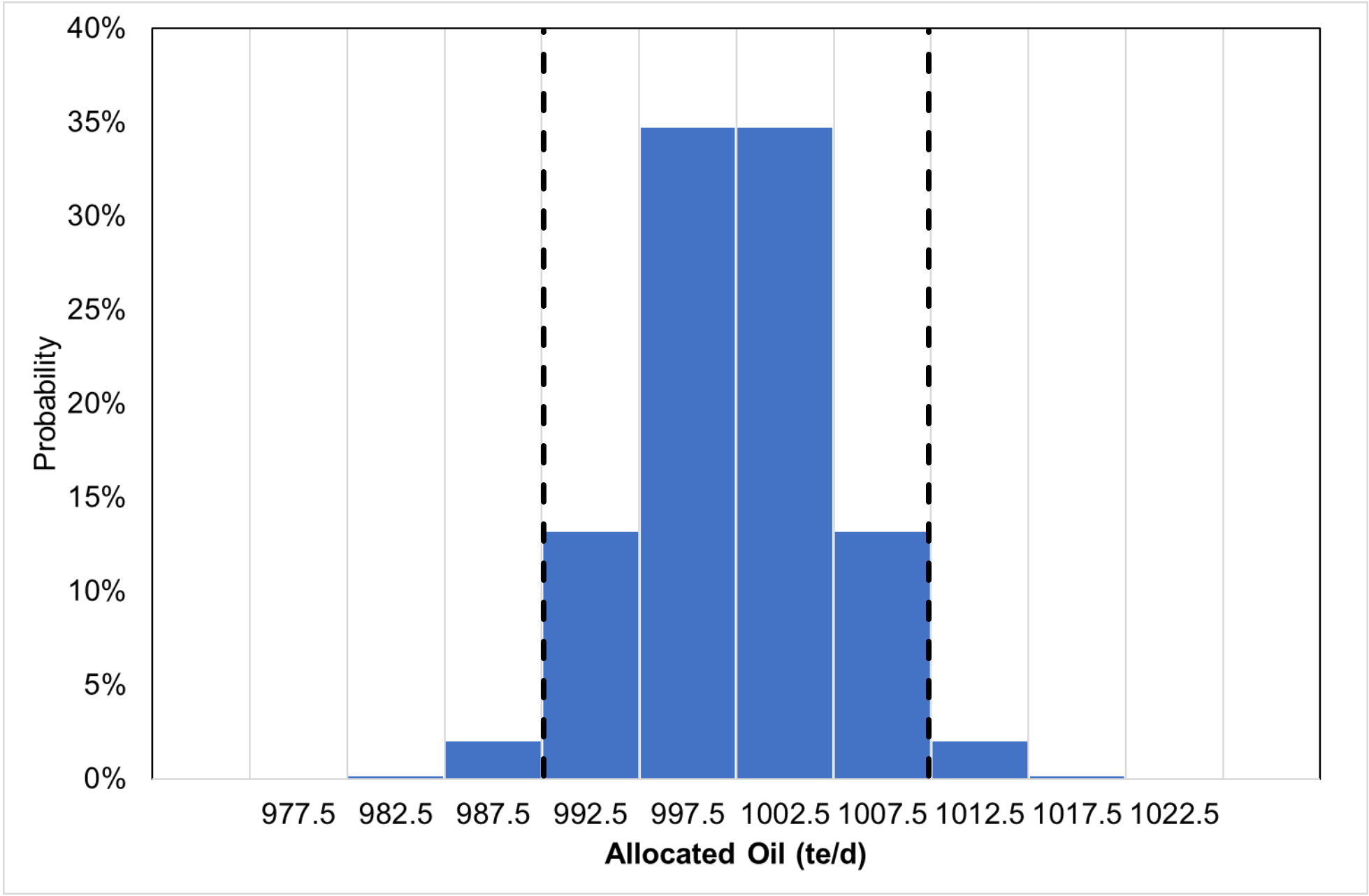

40%
35%
30%
25%
20%
15%
10%
5%
0%
Probability
Loss 27.5 te/d
Loss 22.5 te/d
Loss 17.5 te/d
Loss 12.5 te/d
Loss 7.5 te/d
Loss 2.5 te/d
972.5
977.5
982.5
987.5
992.5
997.5
1002.5
1007.5
1012.5
1017.5
1022.5
1027.5
Allocated Oil (te/d)

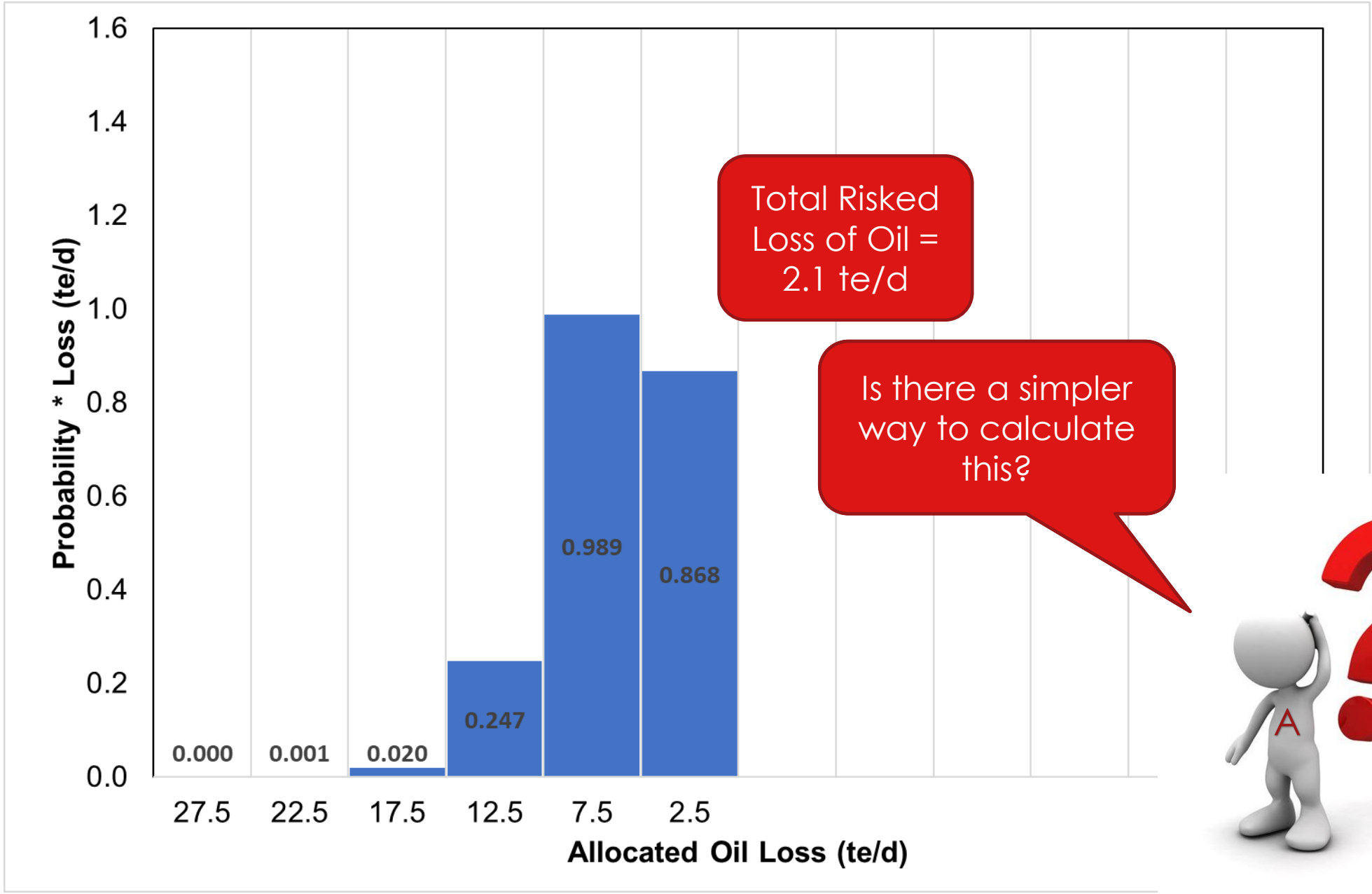

40%
35%
30%
25%
20%
15%
10%
5%
0%
Probability
Loss 27.5 te/d
Loss 22.5 te/d
Loss 17.5 te/d
Loss 12.5 te/d
Loss 7.5 te/d
Loss 2.5 te/d
1.3%
2.9%
5.0%
11.4%
13.4%
16.0%
Risked Loss of Oil = 0.16*2.5 = 0.4 te/d
27.5
22.5
17.5
12.5
7.5
2.5
Allocated Oil Loss (te/d)

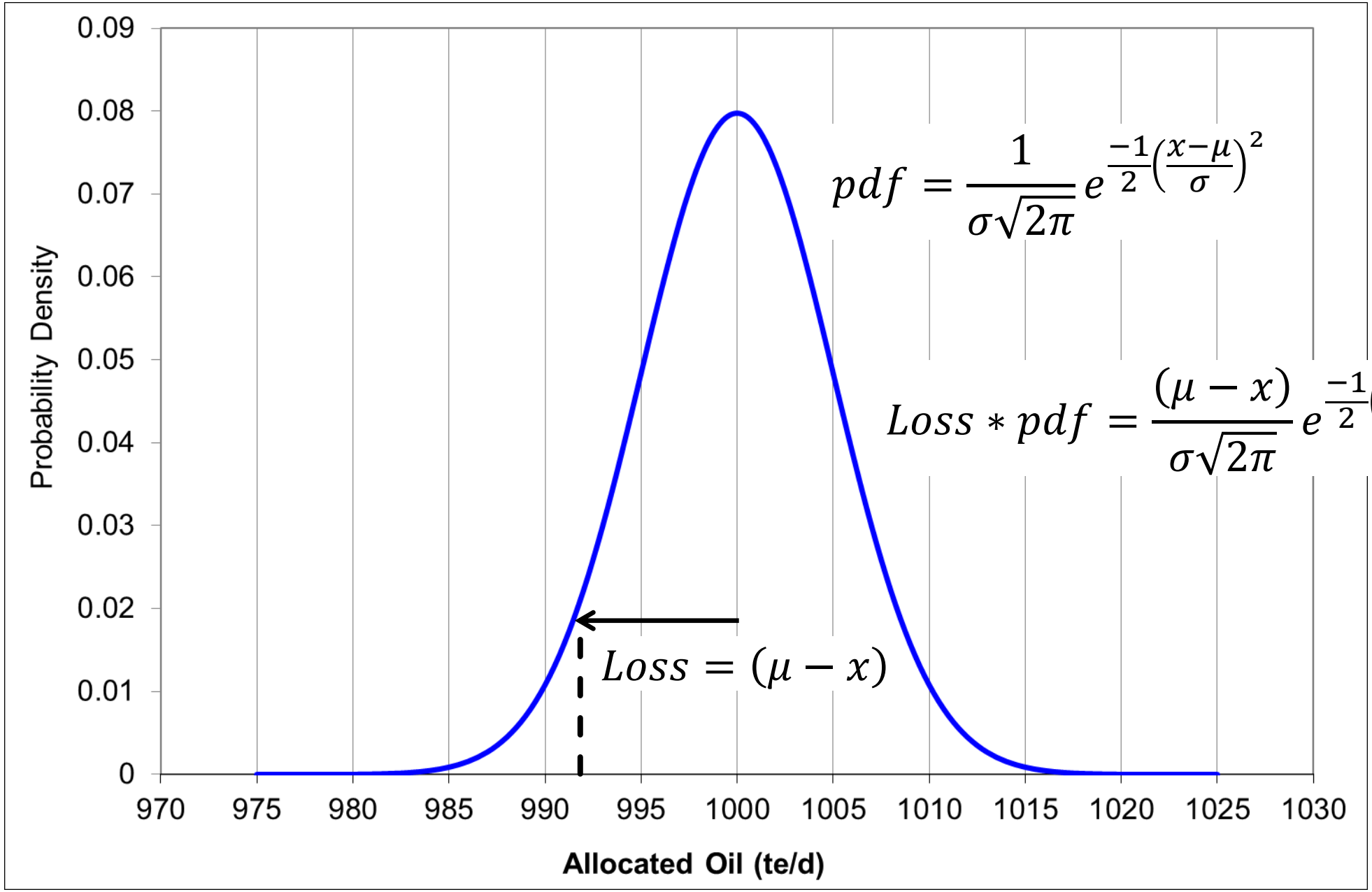

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Probability * Loss (te/d)
0.400
Risked Loss of Oil = 0.16*2.5 = 0.4 te/d
27.5
22.5
17.5
12.5
7.5
2.5
Allocated Oil Loss (te/d)

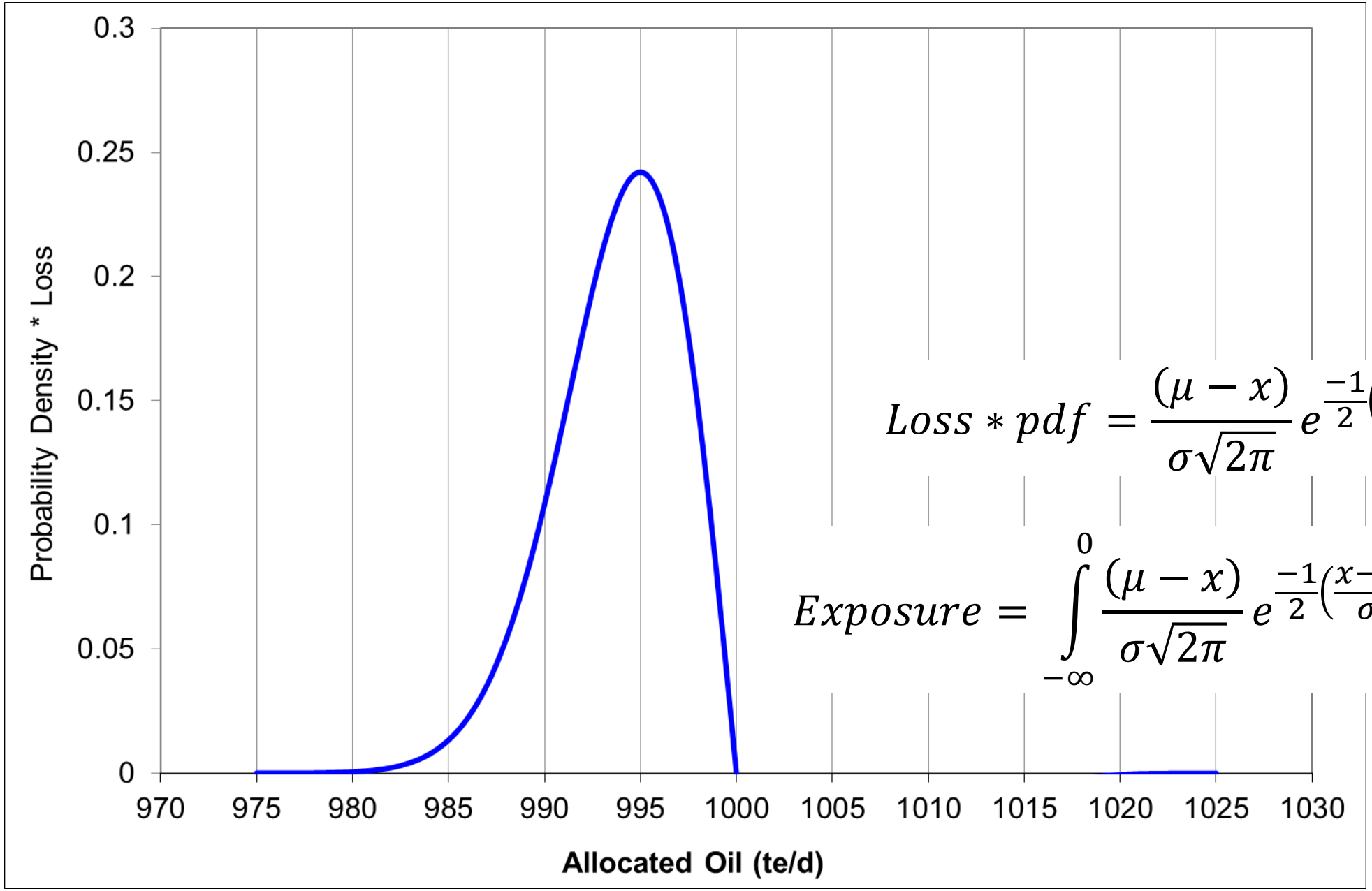

Risked Loss of Oil = 0.134*7.5 = 1.006 te/d
Risked Loss of Oil = 0.16*2.5 = 0.4 te/d
1.006
0.400
Probability * Loss (te/d)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
27.5
22.5
17.5
12.5
7.5
2.5
Allocated Oil Loss (te/d)


1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Probability * Loss (te/d)
0.349
0.652
0.883
1.421
1.006
0.400
27.5
22.5
17.5
12.5
7.5
2.5
Allocated Oil Loss (te/d)
Total Risked Loss of Oil = 4.7 te/d


40%
35%
30%
25%
20%
15%
10%
5%
0%
Probability
977.5
982.5
987.5
992.5
997.5
1002.5
1007.5
1012.5
1017.5
1022.5
Allocated Oil (te/d)

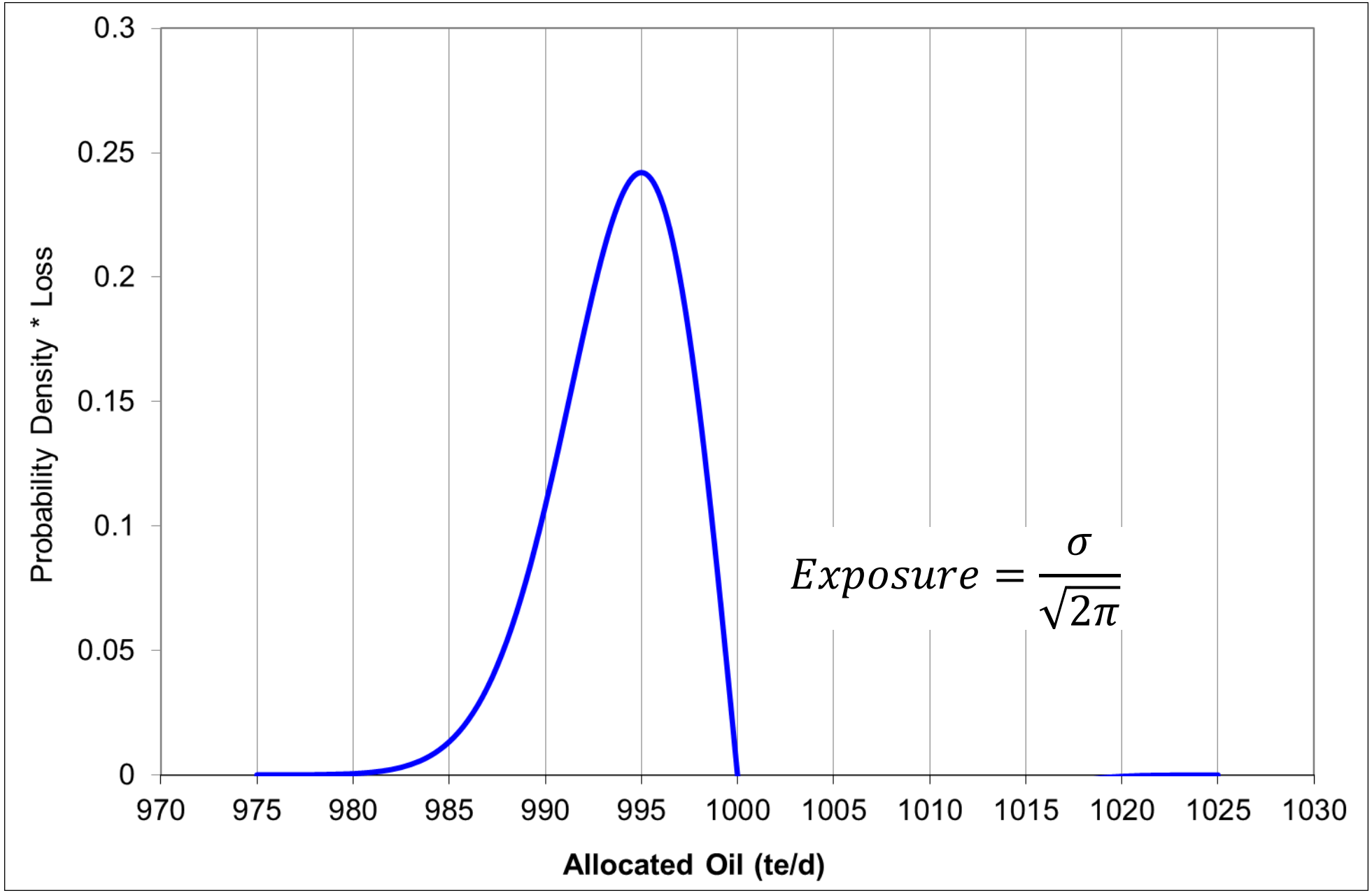

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Probability * Loss (te/d)
0.000
0.001
0.020
0.247
0.989
0.868
27.5
22.5
17.5
12.5
7.5
2.5
Allocated Oil Loss (te/d)
Total Risked Loss of Oil = 2.1 te/d
Is there a simpler way to calculate this?
A

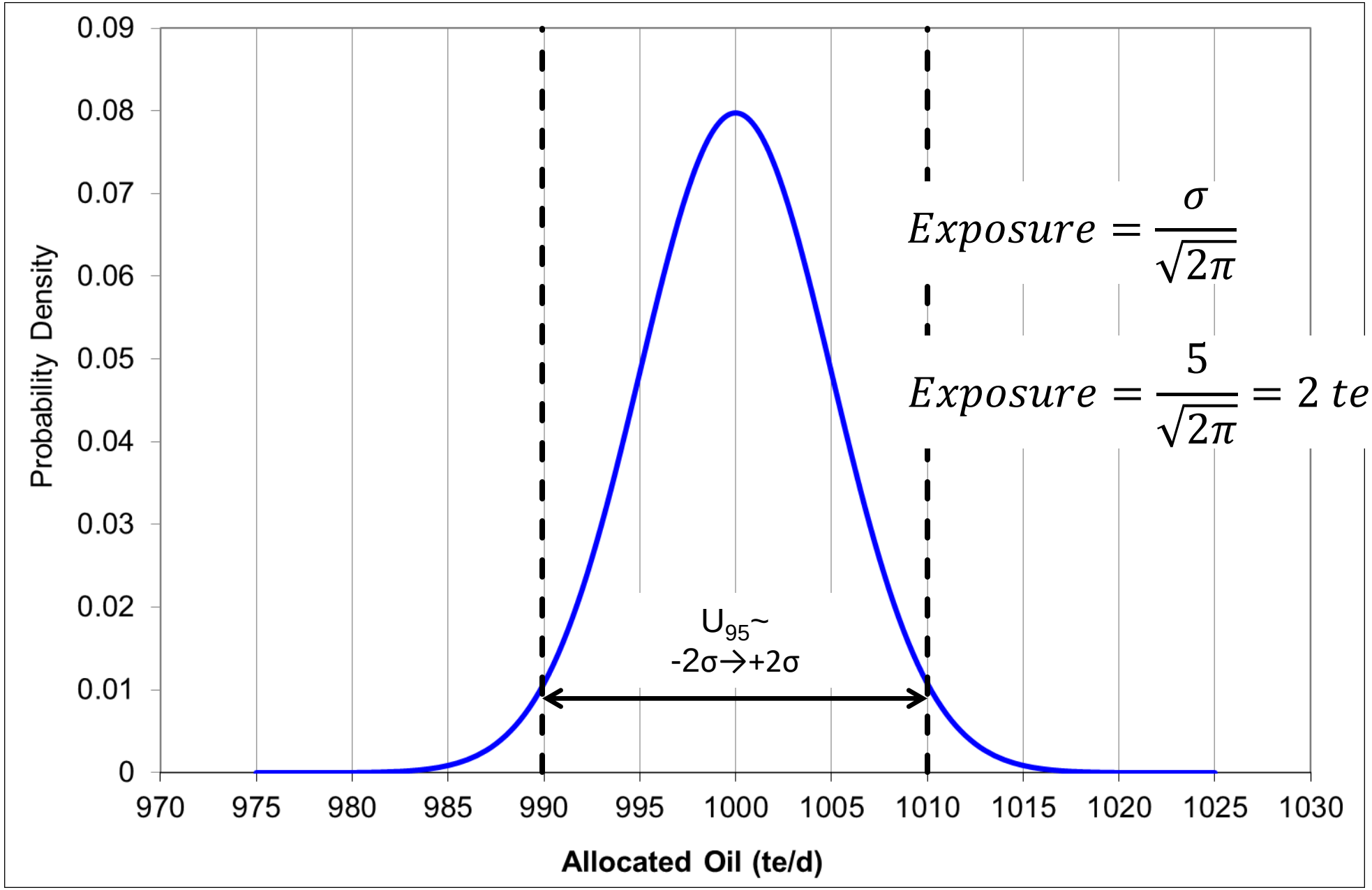

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
$pdf = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$
$Loss * pdf = \frac{(\mu - x)}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$
$Loss = (\mu - x)$

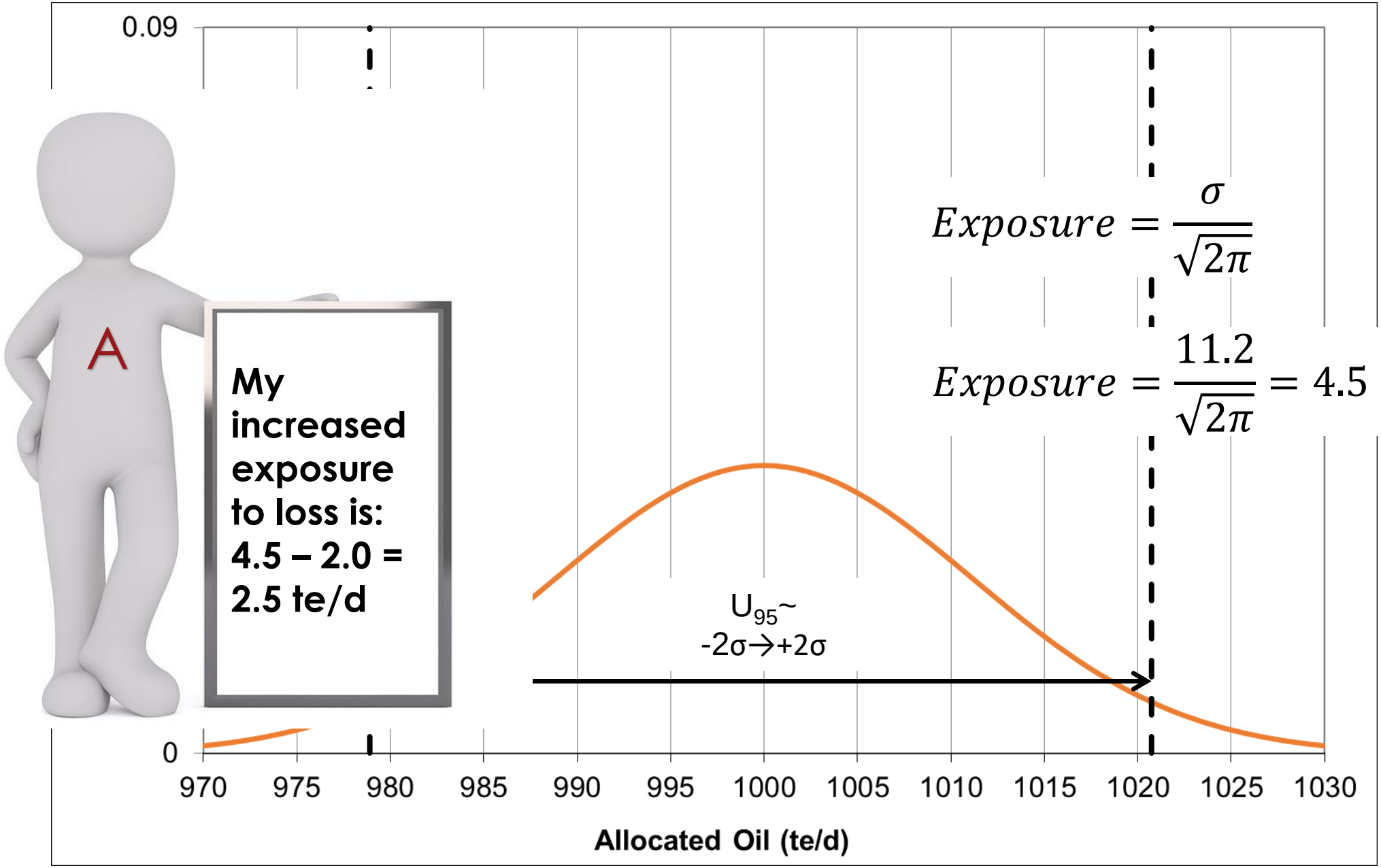


$$Loss * pdf = \frac{(\mu - x)}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

$$Exposure = \int_{-\infty}^{0} \frac{(\mu - x)}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} dx$$


0.3
0.25
0.2
0.15
0.1
0.05
0
Probability Density * Loss
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
$Exposure = \frac{\sigma}{\sqrt{2\pi}}$


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
U95~
-2σ→+2σ
$Exposure = \frac{\sigma}{\sqrt{2\pi}}$
$Exposure = \frac{5}{\sqrt{2\pi}} = 2\ te/d$


0.09
0
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
A
My increased exposure to loss is: 4.5 – 2.0 = 2.5 te/d
U95~ -2σ→+2σ
$Exposure = \frac{\sigma}{\sqrt{2\pi}}$
$Exposure = \frac{11.2}{\sqrt{2\pi}} = 4.5\ te/d$

1. Uncertainty described by the Normal or Gaussian distribution
2. Utility
   a) Loss averse
   b) Indifferent to gains

$$\boldsymbol{Exposure\ to\ Loss = \frac{\sigma}{\sqrt{2\pi}}}$$

$$Exposure\ to\ Loss = \frac{\sigma}{\sqrt{2\pi}}$$

$$Exposure\ to\ Loss = \frac{U_k}{k\sqrt{2\pi}}$$

$$Exposure\ to\ Loss = \frac{U_{95}}{1.96\sqrt{2\pi}}$$

$$Exposure\ to\ Loss \sim 0.2 * U_{95}$$

NORSOK I-106

ANNEX C
System selection criteria (informative)

All measurements have an uncertainty. In fiscal measurement there is a risk for loss of revenue as the measured value may be lower than the true value. Concept with low measurement uncertainty has lower risk for loss of revenue than concepts with higher uncertainty. Metering systems with low uncertainty normally has higher cost than systems with higher uncertainty. The higher cost will also represent a loss of revenue.

Th… a concept with low uncertainty (co… be unreasonab… …
…f a les…

NORSOK I-106

uncertainty
C_A total life cycle costs concept A
C_B total life cycle costs concept B
NPV net present value of the measured quantity
Risk factor (risk for loss / uncertainty at 95 % confidence level) = 0,2

The risk factor has been quantified in section 4 in the paper: Cost Benefit Analyses in the Design of Allocation Systems, by Phillip Stockton, presented at the North Sea Flow Measurement Workshop in 2009.

Concept B may be acceptable if the additional risk for loss is lower than the additional cost for concept A.

Concept B may be acceptable if:

$(C_A - C_B) > (U_B - U_A) * \text{risk fac} \ldots \text{NPV}$

NORSOK I-106

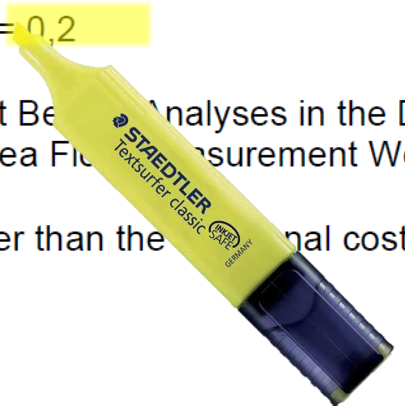
uncertainty
C_A total life cycle costs concept A
C_B total life cycle costs concept B
NPV net present value of the measured quantity
Risk factor (risk for loss / uncertainty at 95 % confidence level) = 0,2

The risk factor has been quantified in section 4 in the paper: Cost Be Analyses in the Design of Allocation Systems, by Phillip Stockton, presented at the North Sea Fl surement Workshop in 2009.

Concept B may be acceptable if the additional risk for loss is lower than the nal cost for concept A.

Concept B may be acceptable if:

$(C_A - C_B) > (U_B - U_A) * \text{risk factor} * NPV$



UK OGA (Now NSTA) Guidelines

4.1 Risk-Based Maintenance Strategies

4.1.1 The OGA expects Operators of both pipelines and individual measurement stations to be open to the adoption of a risk-based approach to maintenance.

4.1.2 In such an approach, Operator experience is used to assess the likely overall effect, in terms of financial exposure, of increased uncertainty in measurement at either the primary or the secondary element, and to balance this against the cost of its mitigation by re-calibration.

4.1.3 In considering the effect of increased measurement uncertainty, it is important use

[5] Pashnina, N & Daniel, P. "Determination of Optimal Calibration Intervals – A Risk-Based Approach." 34th International North Sea Flow Measurement Workshop, St. Andrews 2016.

[6] Stockton, P. "Cost benefit analyses in the design of allocation systems." 27th International North Sea Flow Measurement Workshop, Tønsberg 2009.

[7] Sætre, C. et. al "A new methodology for cost-benefit risk analysis of oil metering system lay-outs." 33rd International North Sea Flow Measurement Workshop, Tønsberg 2015

[8] https://nfogm.no/documents/north-sea-flow-measurement-workshop/

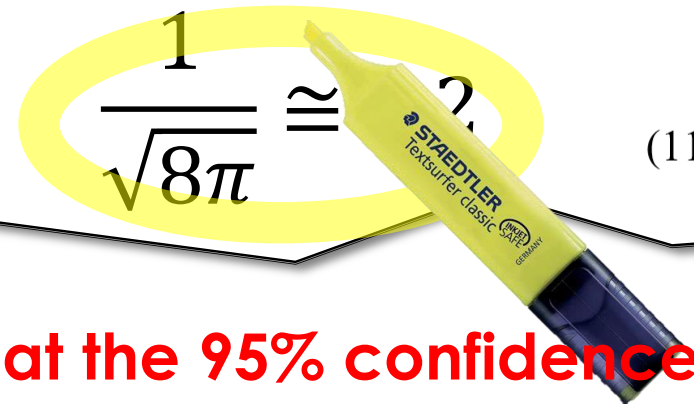
NSFMW 2009 Paper

The total exposure to lost revenue is found between x1 equal to minus infinity and x2 equal to x_{mean}. R then reduces to:

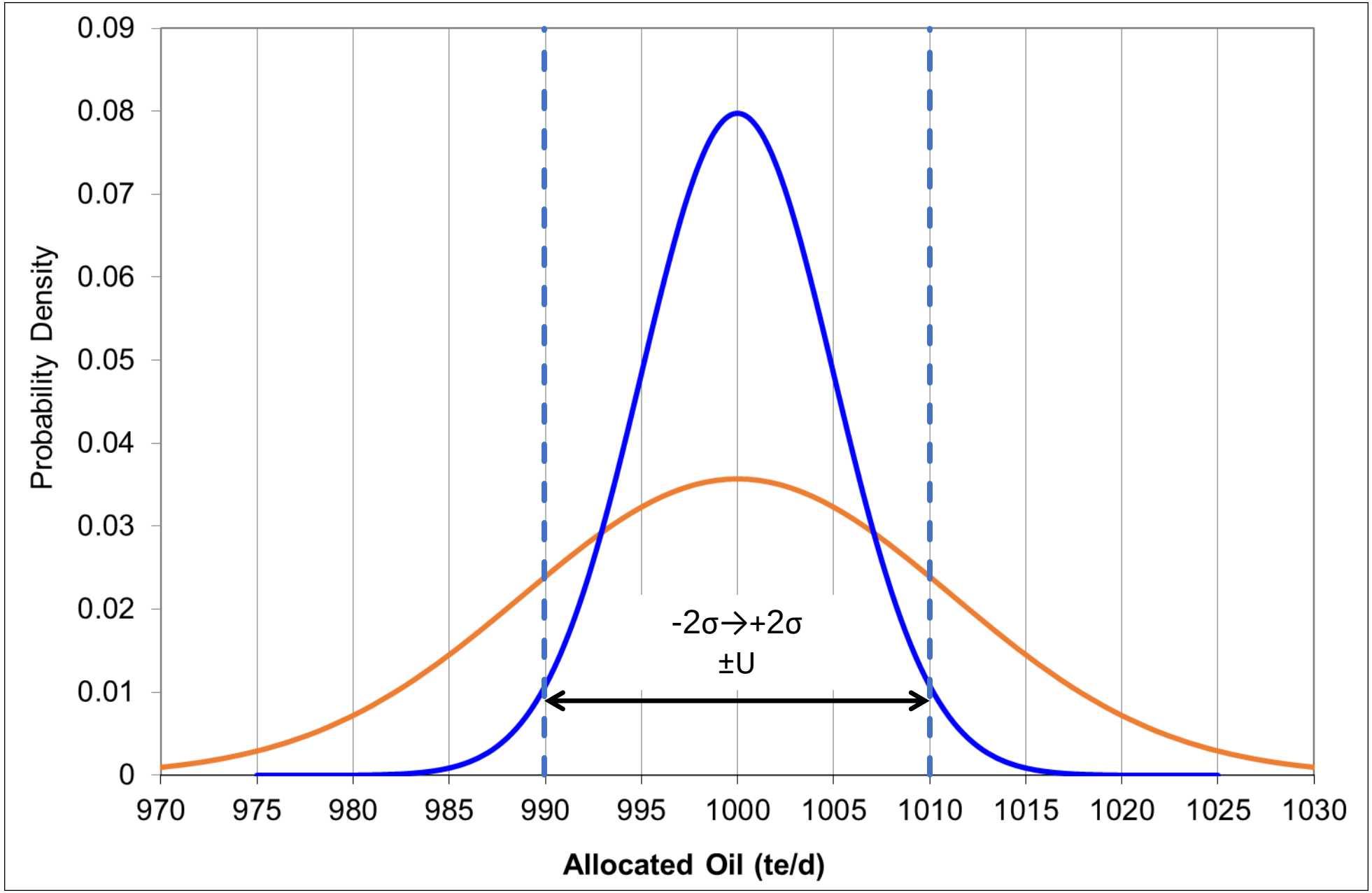
$$R = \frac{-\sigma}{\sqrt{2\pi}} \tag{10}$$

The value of L is the negative of R and can be expressed in terms of the uncertainty (equal to twice the standard deviation).

$$L = \frac{U}{\sqrt{8\pi}} \cong \frac{1}{2} \tag{11}$$

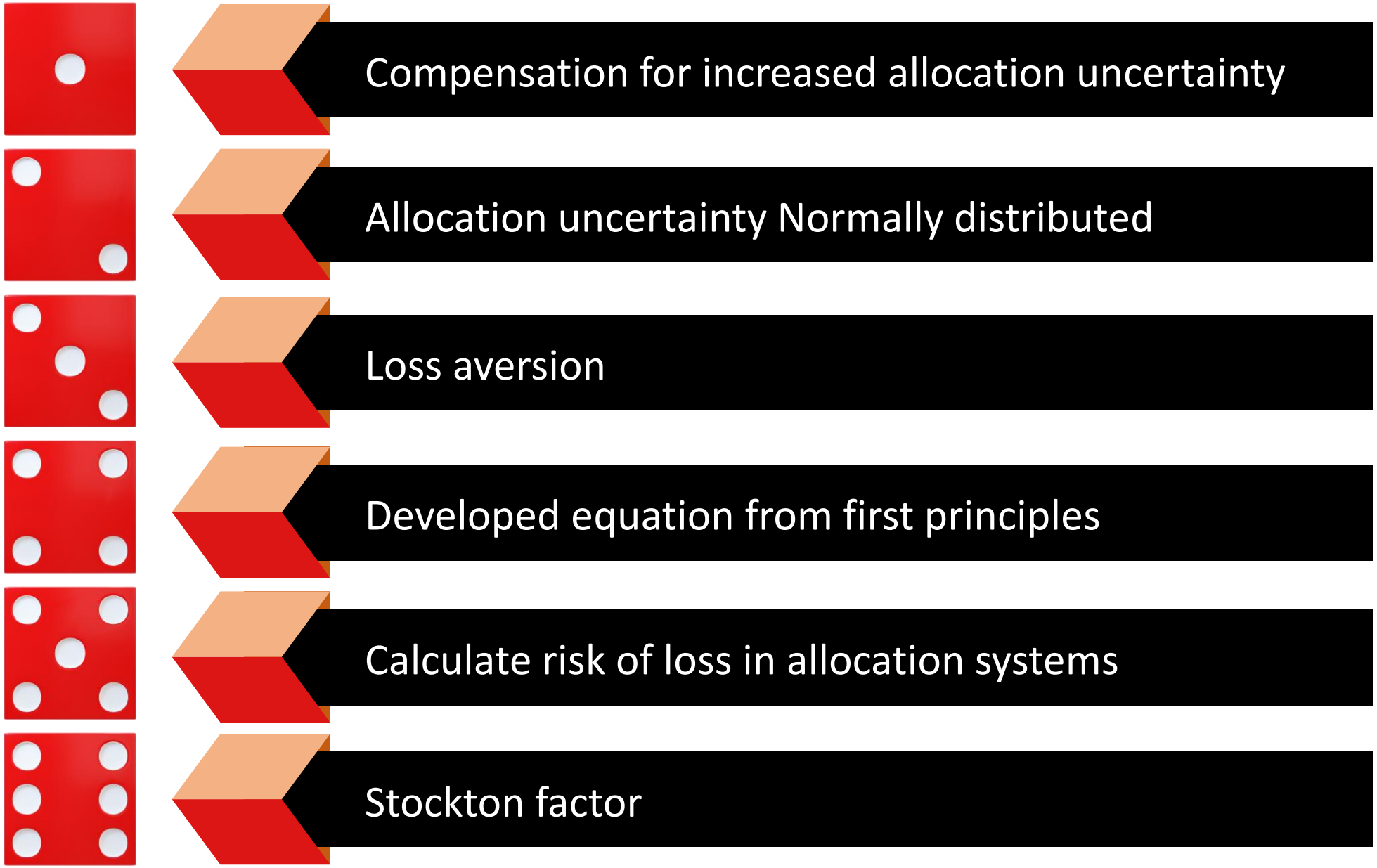


Only applies when U is expressed at the 95% confidence level !


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Probability Density
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
Allocated Oil (te/d)
-2σ→+2σ
±U


IF THE ONLY TOOL YOU HAVE
IS A HAMMER, YOU TEND TO
SEE EVERY PROBLEM AS A NAIL
- ABRAHAM MASLOW


Simple Example
Risk and Return
Uncertainty and the Normal Distribution
Risk and Loss Aversion
Integrated Risk of Loss
Conclusions


Compensation for increased allocation uncertainty
Allocation uncertainty Normally distributed
Loss aversion
Developed equation from first principles
Calculate risk of loss in allocation systems
Stockton factor

Google

stockton factor

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- Total Theatre
http://totaltheatre.org.uk › archive › features › stockto...

The Stockton Factor | Total Theatre Magazine Print Archive

One of the pioneers in this sea-change of opinion is the **Stockton** International Riverside Festival, which recently celebrated its 16th year.

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Allocation Uncertainty - 3.2 Stockton, Accord ESL

This paper describes methods of analytically calculating allocation uncertainties. It also highlights potential pitfalls and how to avoid them in typical ...
32 pages

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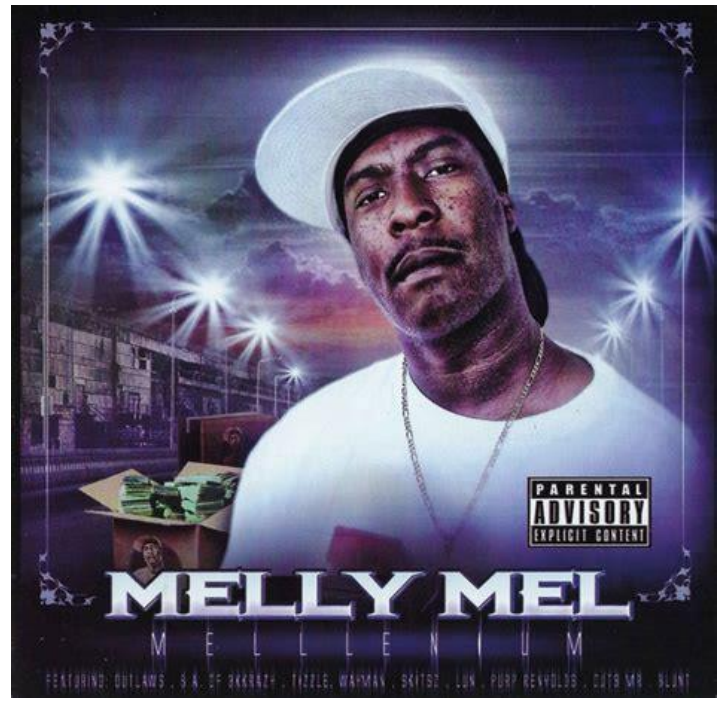
Express Engine Parts Teeside, Stockton-On-Tees

See results about

Stockton Factor
Song by Melly Mel



OpenAI
ChatGPT 4.0

PH

PH