Practical applications of uncertainty in allocated figures

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NFOGM Hydrocarbon Management Workshop
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Assessing uncertainty in allocated figures

Ref. Aker BP presentation 2023* and expanding context:

WHEN?
Anytime. Pre-operation: tie-in agreement & Operation: actual production

WHO?
Anyone involved

WHY?
Commercial and operational risk management, evaluation of operational challenges and actions

WHAT?
Frequent uncertainty and risk updates

HOW?
Common knowledge and new standard tools

* Practical use of allocation uncertainty analyses, Marta Szwangruber, Aker BP, HCM Workshop 2023 (nfogm.no)

HOW?
The fundamentals:

- Build on
  - Uncertainty in measurement theory (ISO GUM)
  - Cost benefit analyses (P.Stockton, NSFMW 2009 / NORSOK I-106)
- Analytical methods limited
- Likely need to always use numerical method

Analytical = simple allocation formulas

$$U_R = \sqrt{(U_A)^2 + (U_B)^2 + (U_C)^2}$$ Eq. 7-2

$$(U_{Q1})^2 = \frac{X_1^2}{(X_1 + X_2)^2} * (U_Q)^2 + \frac{Q^2}{(X_1 + X_2)^4} * \left[X_2^2 * (U_{X1})^2 + X_1^2 * (U_{X2})^2 \right]$$ Eq. 7-5 Energy institute HM96 (2012)

Numerical (Monte Carlo) = complex allocation formulas

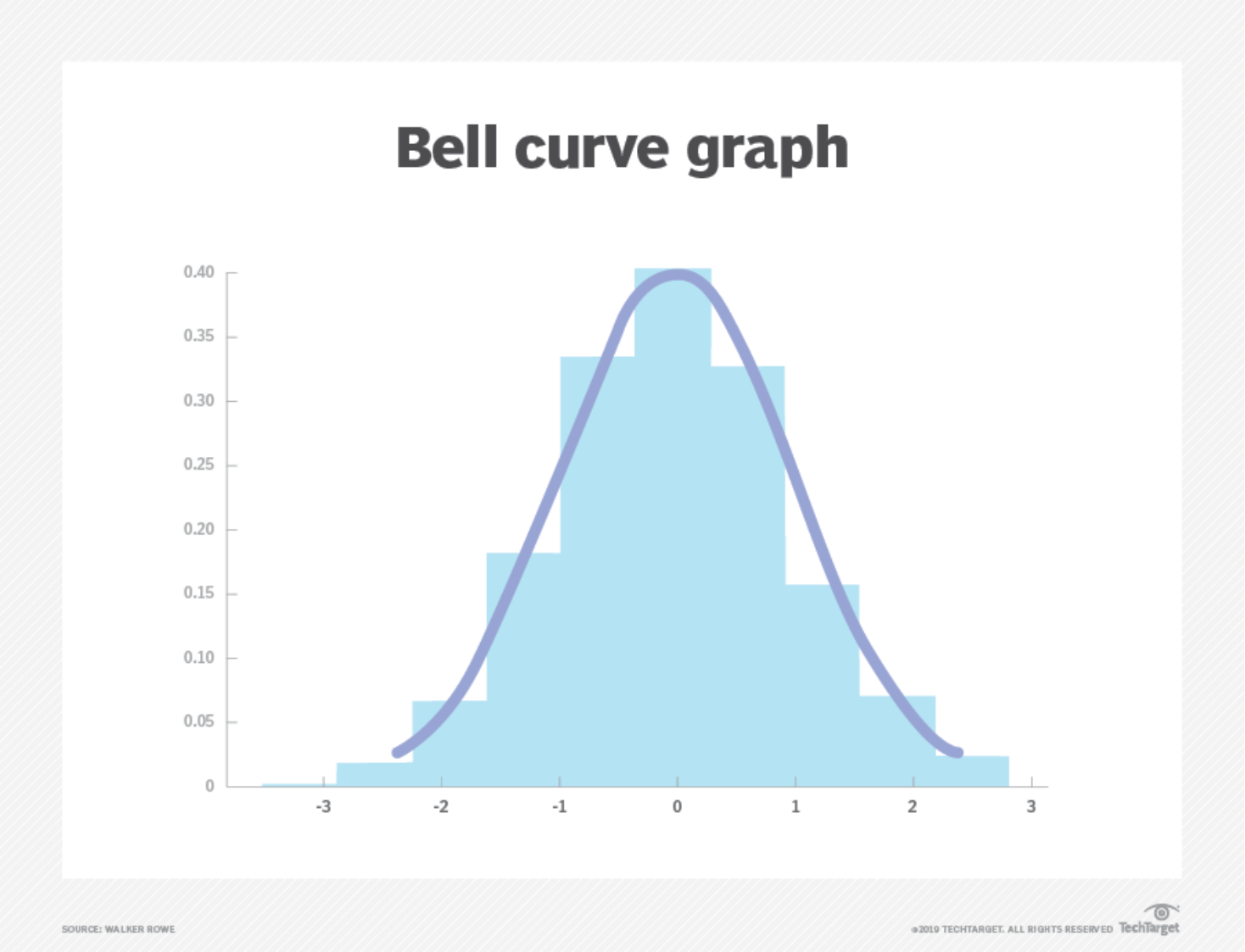
	Allocated quantity		
	Field 1	Field 2	Field 3
Average [kg/d]	82 096.95	29 389.00	518 587.66
2*STD.DEV [%]	14.2 %	11.1 %	2.7 %
Total HC RfL [MNOK]	18.5	11.4	23.1
Gas RfL [MNOK]	4.3	0.9	4.8
Gas RfL [kg]	850 438.5	237 871.5	1 002 461.7
Abs unc. [MNOK]	21.8	4.4	24.3
Abs unc. [kg]	4 263 466.6	1 192 511.1	5 025 597.5
Result Sim.No			
1	84 724.5	27 504.8	513 467.7
2	85 497.9	30 625.2	521 330.7

HOW?
What is a Monte Carlo Simulation?

- Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to obtain numerical results.

- The underlying concept is to use randomness to solve problems that might be deterministic in principle.

(Wikipedia)



HOW? Uncertainty budget

- Calculate uncertainty using a structured approach, typically following the ISO GUM method
- Alternative / supplemental to Monte Carlo simulations
- Evaluation of uncertainty contributors

Uncertainty budget	U* from Monte Carlo (%)	28.4 %							
Field x alloc. gas (kg/d)	U* from budget (%)	27.8 %							
Input variable	**Input Rel. Exp. Unc. (k=2)**	**Input Std. Unc. (k=1)**	**x**	**y (kg/d)**	**x2**	**y2 (kg/d)**	**Rel. Sensitivity Coeff.**	**Variance**	**Contribution**
Measured oil volume (Sm3/d)									
Field1	15.0 %	7.50 %					-0.365798551	0.00075	3.9 %
Field2	10.7 %	5.35 %					-0.067374024	1.3E-05	0.1 %
Field3	0.0 %	0.00 %						0	0.0 %
Field4	5.0 %	2.50 %					-0.003707178	8.6E-09	0.0 %
Field5	4.8 %	2.38 %					-0.204094844	2.4E-05	0.1 %
Field6	10.0 %	5.00 %					-3.54524E-15	3.1E-32	0.0 %
Measured gas volume (MSm3/d)								0	0.0 %
Field1	15.0 %	7.50 %					-0.39992008	0.0009	4.7 %
Field2	13.3 %	6.63 %					-0.013350616	7.8E-07	0.0 %
Field3	0.0 %	0.00 %						0	0.0 %
Field4	5.0 %	2.50 %					-0.087655407	4.8E-06	0.0 %
Field5	6.6 %	3.30 %					-3.182030121	0.01103	57.3 %
Field6	10.0 %	5.00 %					0	0	0.0 %
Density - oil (kg/Sm3)									
Field1	5.0 %	2.50 %					-0.365798551	8.4E-05	0.4 %
Field5	5.0 %	2.50 %					-0.204094844	2.6E-05	0.1 %
Density - gas (kg/Sm3)									
Field1	5.0 %	2.50 %					-0.39992008	1E-04	0.5 %
Field5	5.0 %	2.50 %					-3.182030121	0.00633	32.8 %
							Sum of variances	0.01926	100.0 %
							Relative standard uncertainy, U	13.9 %	
							Relative expanded uncertainy, U* (k=2)	27.8 %	

isobudgets.com

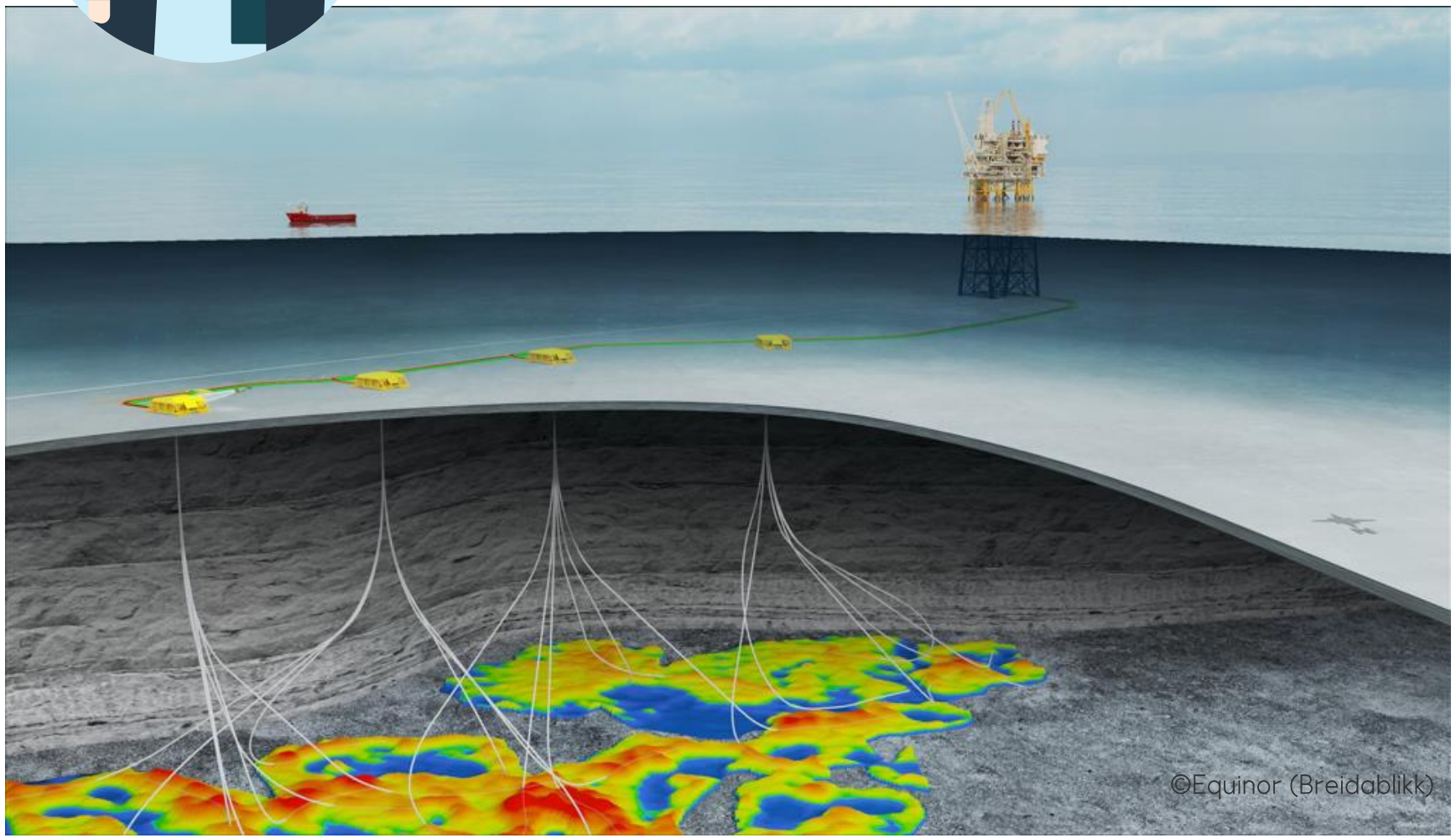
WHEN? WHY? Pre-operation: Tie-in agreement

Operator:

- Evaluation of allocation principles
- Fair principle and acceptable uncertainty in allocated quantities for all licenses

Partners:

- Fair share of the production quantities
- Acceptable level of uncertainty and risk in our allocated quantities



WHEN? WHY? Operation: production phase

Operator:

- Any change from pre-operations?
- Challenges in operations affecting uncertainty?

Partners:

- Level of uncertainty and risk in our allocated quantities in operation?

Allocation agreement:

- Review of allocation procedure?

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Norwegian "Regulations relating to fiscal measurement in the petroleum activities" (rev. May 2023)

§25 (2) "The allocation system shall be validated within a reasonable time after it has been put into operation and thereafter in the event of changes that may affect the validity of the system."

LOVDATA

Forskrift om fiskal måling i petroleumsvirksomheten (måleforskriften)

Del paragraf

Kapittel 6. Krav til allokering

§ 23. *Allokeringssystem*

(1) Rettighetshaver skal ha et allokeringssystem som sikrer at produsert petroleum allokeres rettferdig mellom rettighetshavere. Allokerte mengder petroleum skal kunne kvalitetssikres og revideres.

(2) Valg av allokeringsmetode og tilstandsligninger (ligninger som angir sammenhengen mellom trykk, volum og temperatur for et fluid) skal kunne dokumenteres.

(3) Måleinstrumenter og målesystem som anvendes for å fremskaffe verdier til inngangsstørrelser i en allokering skal kunne identifiseres.

Del paragraf

§ 24. *Allokeringsprosedyrer*

Allokeringsprosedyrer skal være etablert før allokeringssystemet tas i bruk.

Del paragraf

§ 25. *Verifisering og validering*

(1) Rettighetshaver skal verifisere allokeringsberegninger før de tas i bruk og etter endringer.

(2) Allokeringssystemet skal valideres innen rimelig tid etter at det er tatt i bruk og deretter ved endringer som kan påvirke validiteten til systemet.

Del paragraf

WHEN? WHY?
Examples of practical applications in operational phase

- Actual production and fluids different from predicted
- Metering challenges
- Inadequate sampling/laboratory analyses
- Change in operational strategy: maximise liquid or gas
- Etc.

➔Estimate effect on uncertainty in allocated figures

➔Identify actions to mitigate challenges

Common challenge:

- Estimate of realistic uncertainty span for all input data
- In-depth analysis of uncertainty in metering systems?
- Establish common practice for other typical input data?
- Qualitative simulation results still useful for screening of risk, comparison and decision taking?

Heidrun CCR @GCCD/Equinor

Future

WHEN?
Anytime. Pre-operation: tie-in agreement & Operation: actual production

WHO?
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WHAT?
Frequent uncertainty and risk updates

HOW?
Common knowledge and new standard tools

New IT tools for frequent assessment of uncertainty in allocated quantities?

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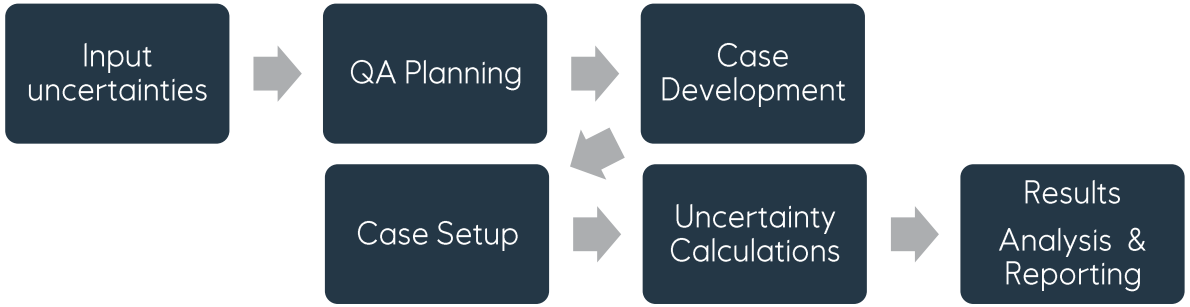

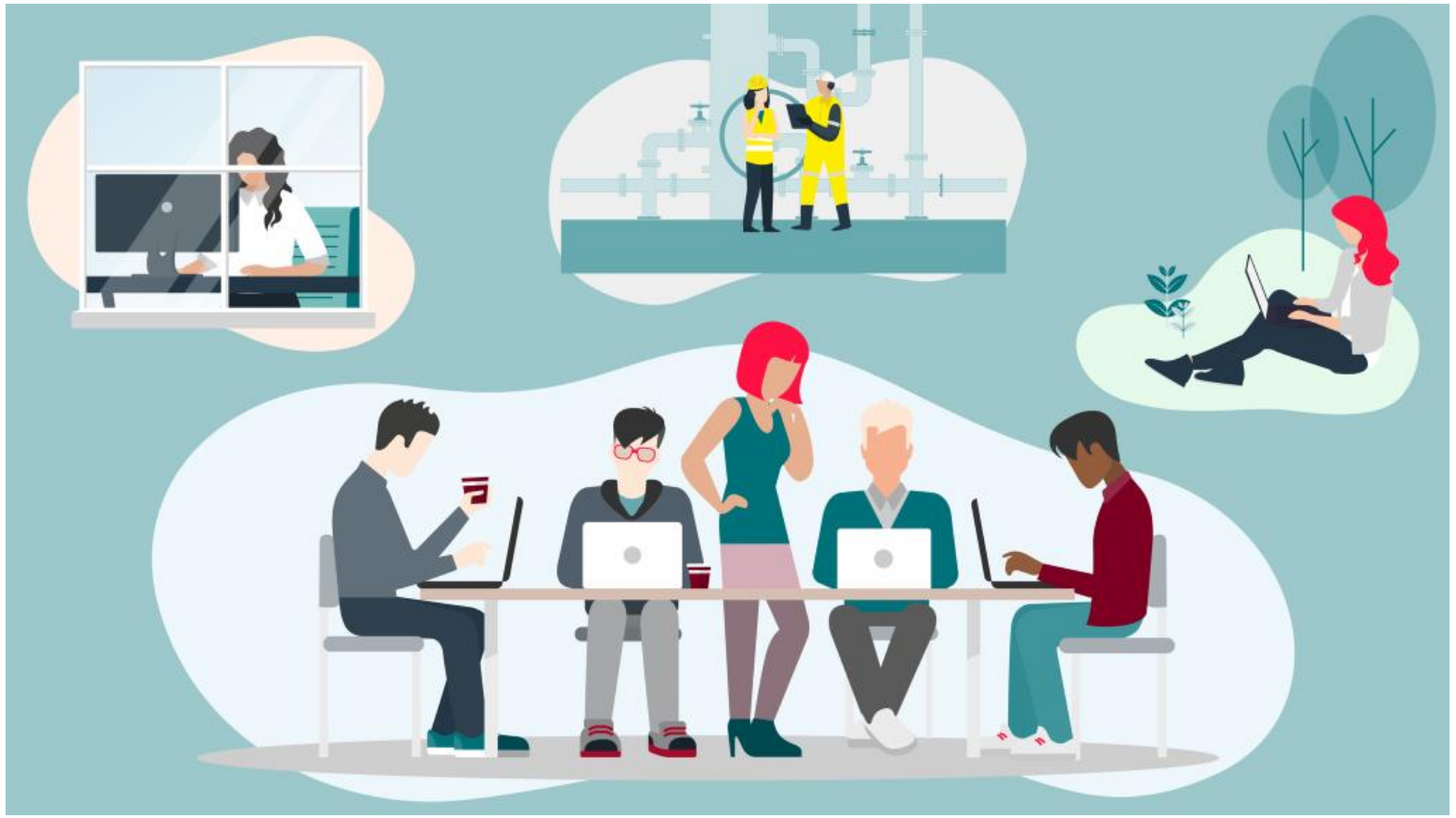

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VISION or possible to get there SOON?

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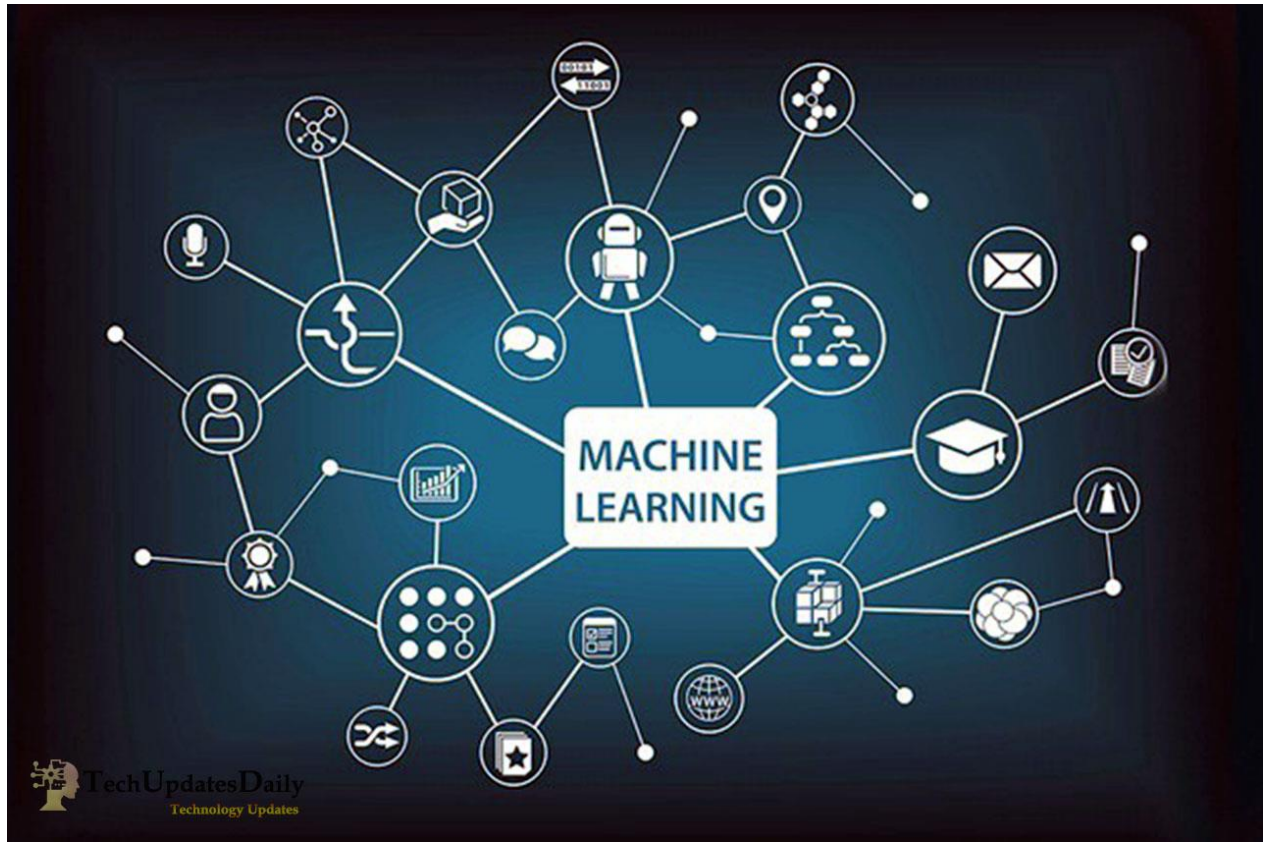
- Additional possibilities with use of AI / Machine Learning based on available historic and predicted data?
  - Suggest uncertainty span for input variables?
  - Continuous monitoring of uncertainty?
  - Suggest actions to reduce uncertainty?



Machine Learning: What Is Machine Learning? - TechUpdatesDaily

“Monte Carlo” is popular reference…

Monte Carlo simulations are named after the famous Monte Carlo Casino in Monaco.

http://wallsdesk.com/monte-carlo-88251/

Monte Carlo fun facts.....

- Movies (imdb.com): 70+ search hits

Monte Carlo
2011
Selena Gomez, Leighton Meester

Those Daring Young Men in Their Jaunty Jalopies
1969
Bourvil, Lando Buzzanca

Herbie Goes to Monte Carlo
1977
Dean Jones, Don Knotts

We Go to Monte Carlo
1953
Audrey Hepburn, Jules Munshin

Monte Carlo
1930
Jeanette MacDonald, Jack Buchanan

Charlie Chan at Monte Carlo
1937
Warner Oland, Keye Luke

Mission: Monte Carlo
1974
Roger Moore, Tony Curtis

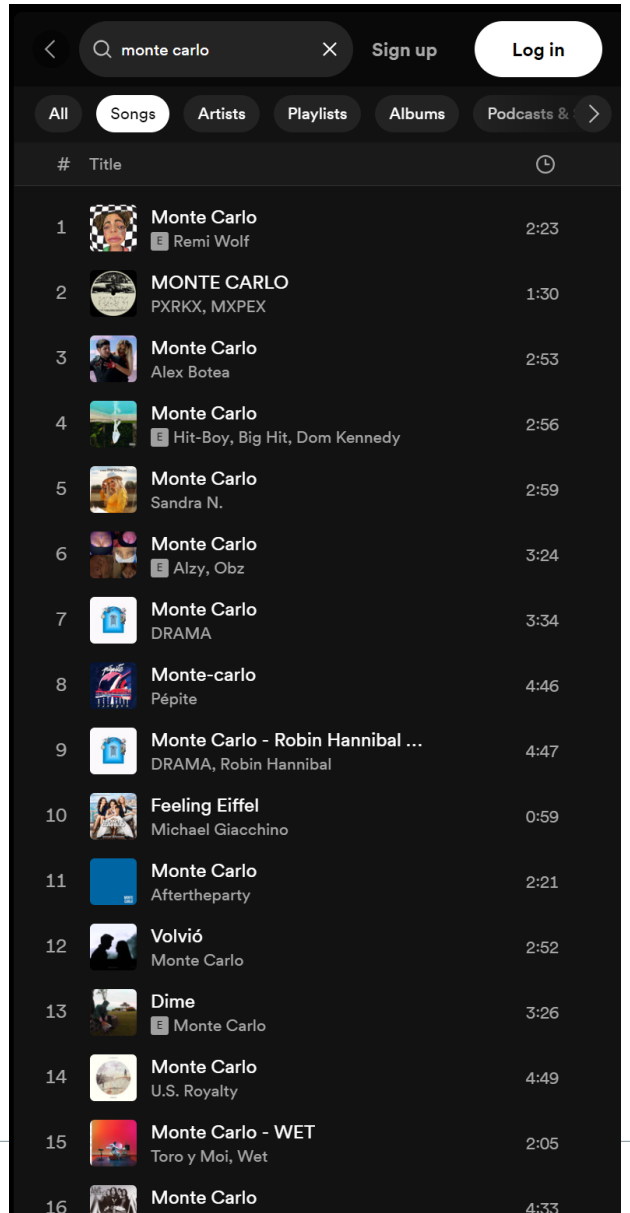
Nous irons à Monte Carlo
1951
Ray Ventura, Henri Génès

Monte Carlo Nights
1934
Mary Brian, John Darrow

Affair in Monte Carlo
1952
Merle Oberon, Richard Todd

The Widow from Monte Carlo
1935
Warren William, Dolores Del Río

- Music (spotify.com): 500+ search hits



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