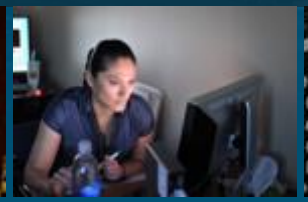
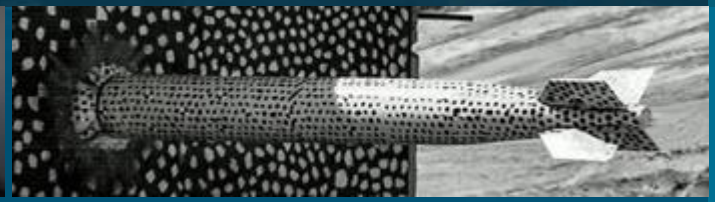
JOURNEY TO A DATA CENTRIC APPROACH FOR NATIONAL SECURITY





PRESENTED BY

Marcey Hoover, PhD

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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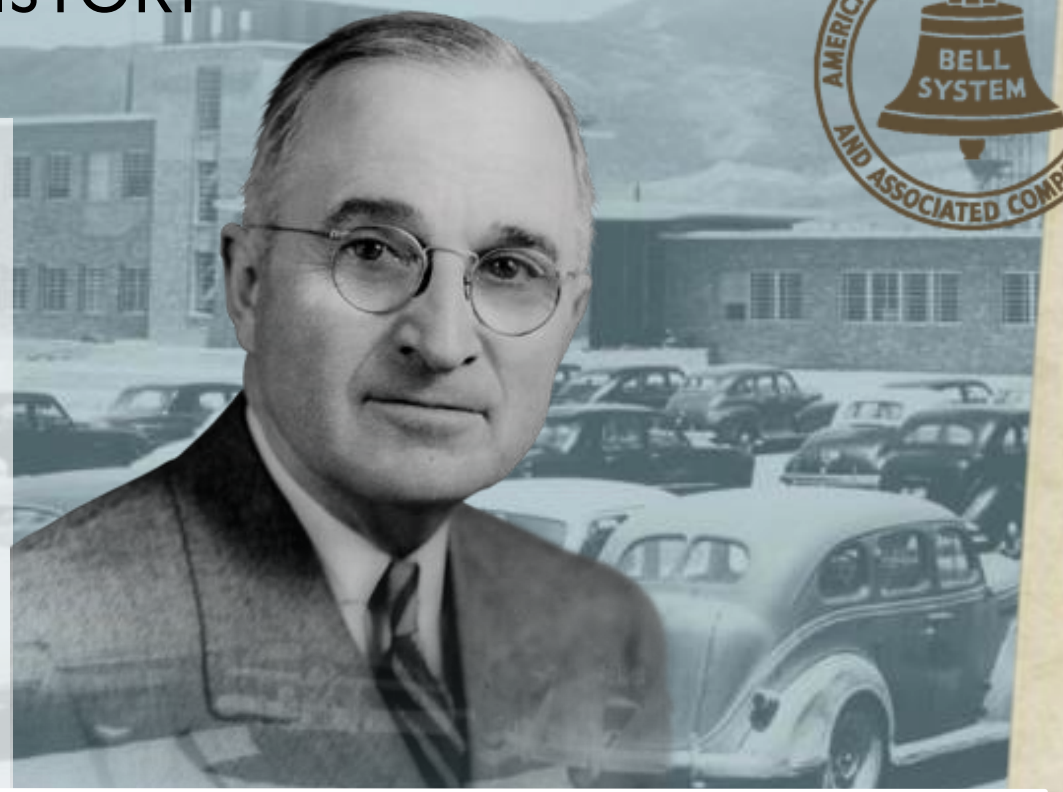
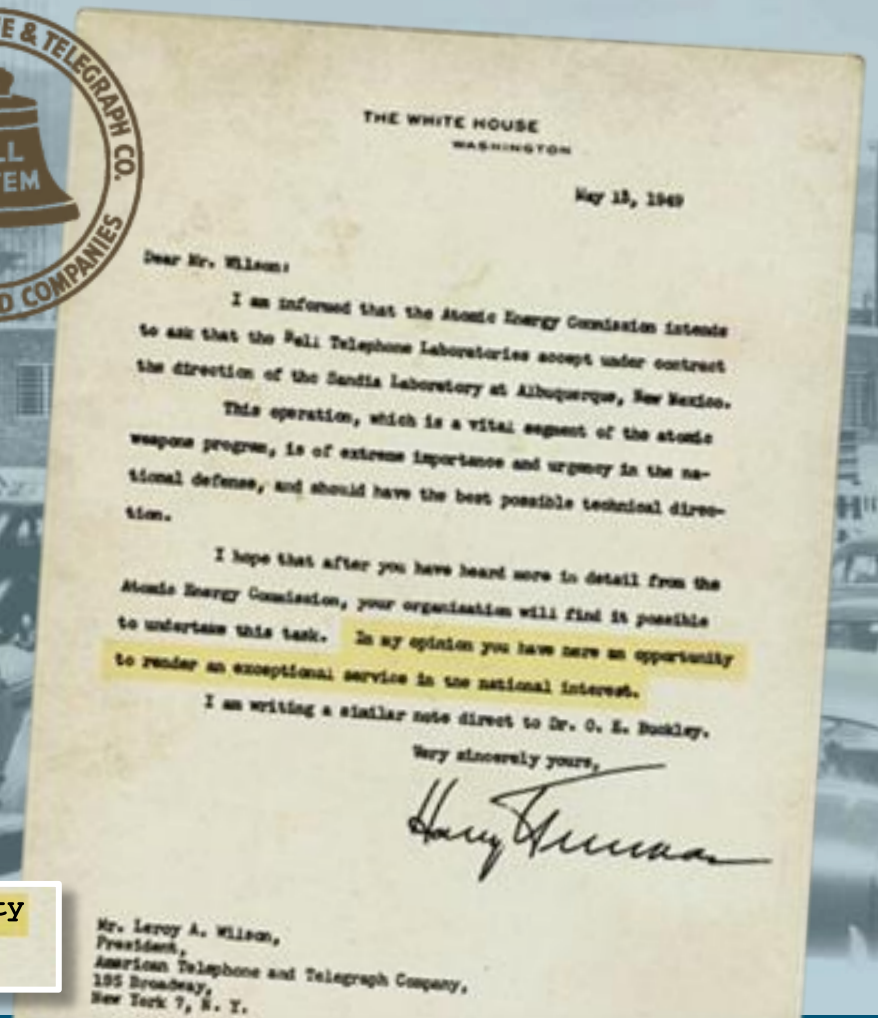
SANDIA'S HISTORY

- July 1945: Los Alamos creates Z Division
- Nonnuclear component engineering
- November 1, 1949: Sandia Laboratory established





THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. C. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

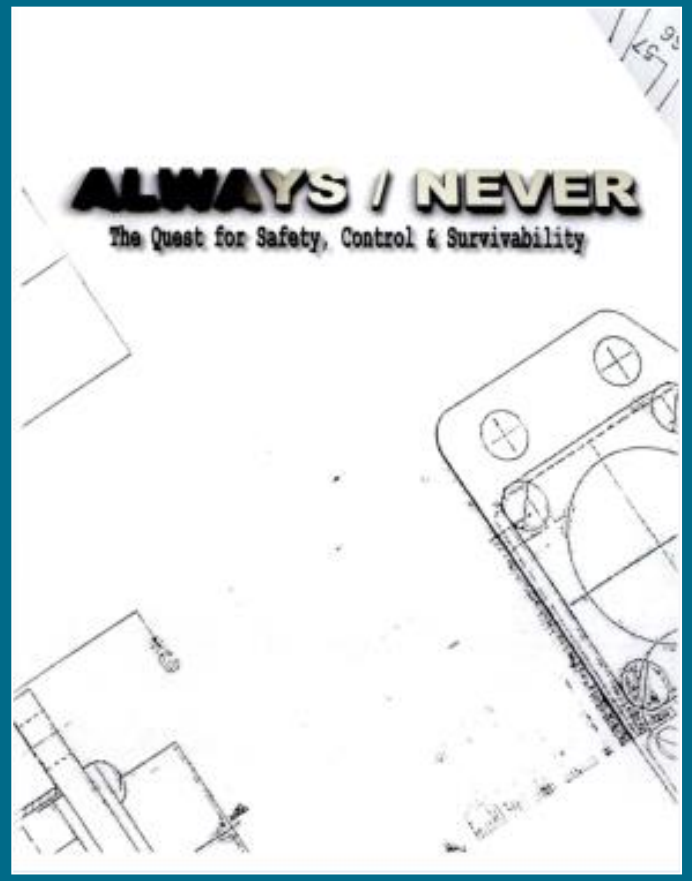
to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

A HIGH-CONSEQUENCE ENGINEERING CHALLENGE

The Garaged Mustang

- Ready to drive after 40 years in the garage?
- **Our products must work at a moment's notice — even after decades of storage**

AN ADDITIONAL ENGINEERING CHALLENGE

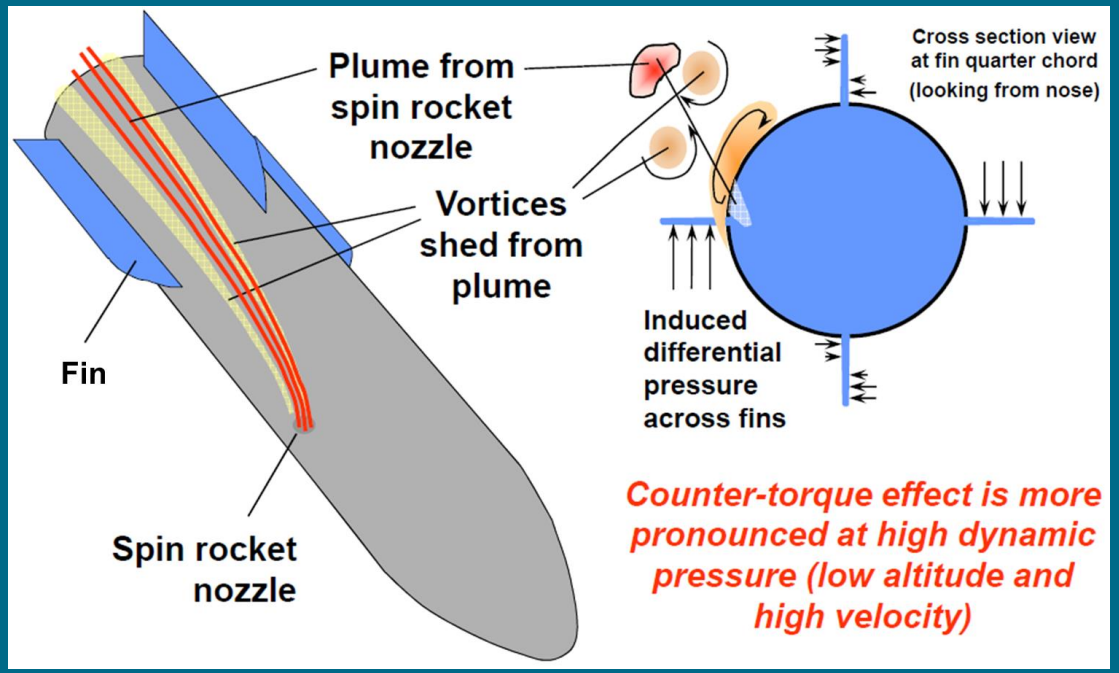


FLIGHT TEST

Show video:
https://www.youtube.com/watch?v=xhs4VQ9dN3s

NOT ALL FLIGHT TESTS GO SO SMOOTHLY

- In the late 1990s, Sandia experienced a flight test failure due to a failure to pass electrical signals through a key component
- The failure prompted a review of all data, which uncovered a complex jet-fin interaction affecting the spin rate
- This was the beginning of our journey towards a more **data-driven approach**



CULTURE CHANGE: A PROACTIVE APPROACH

PERFORMANCE DATA COLLECTION AND ANALYSIS

DESIGN QUALIFICATION

QUANTITATIVE MARGIN ANALYSES

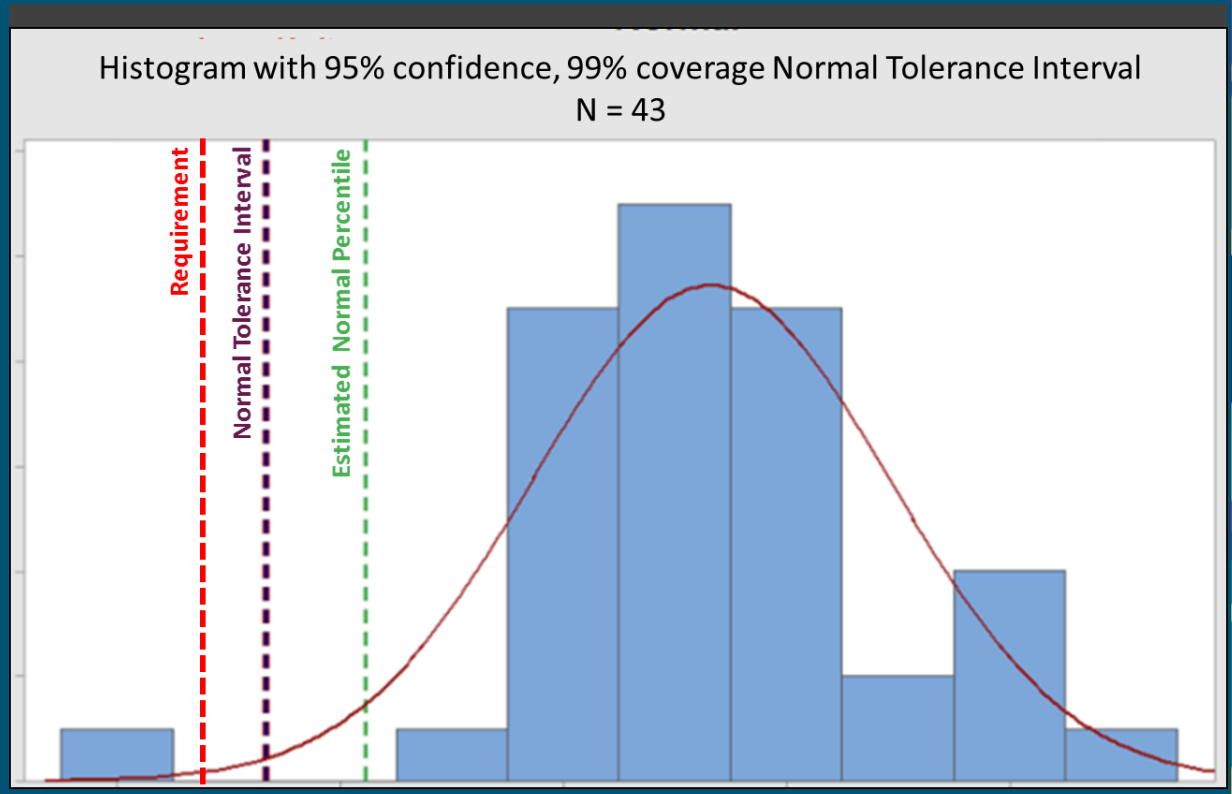
TEAMING IS PARAMOUNT

REVELATION: STATISTICS IS NOT A MAGICAL SOLUTION

Ideally would like to claim: We are XX% confident that YY% of units will meet the requirement.

Practical challenges for this claim:

- Test data measurement uncertainty
- Model uncertainty
- Experts state of knowledge is imperfect
- Information comes from heterogeneous sources that are difficult to combine
- Separation of stochastic and knowledge uncertainty is infeasible
- Not all uncertainties can be straightforwardly quantified



Blindly applying statistical methods can be misleading!

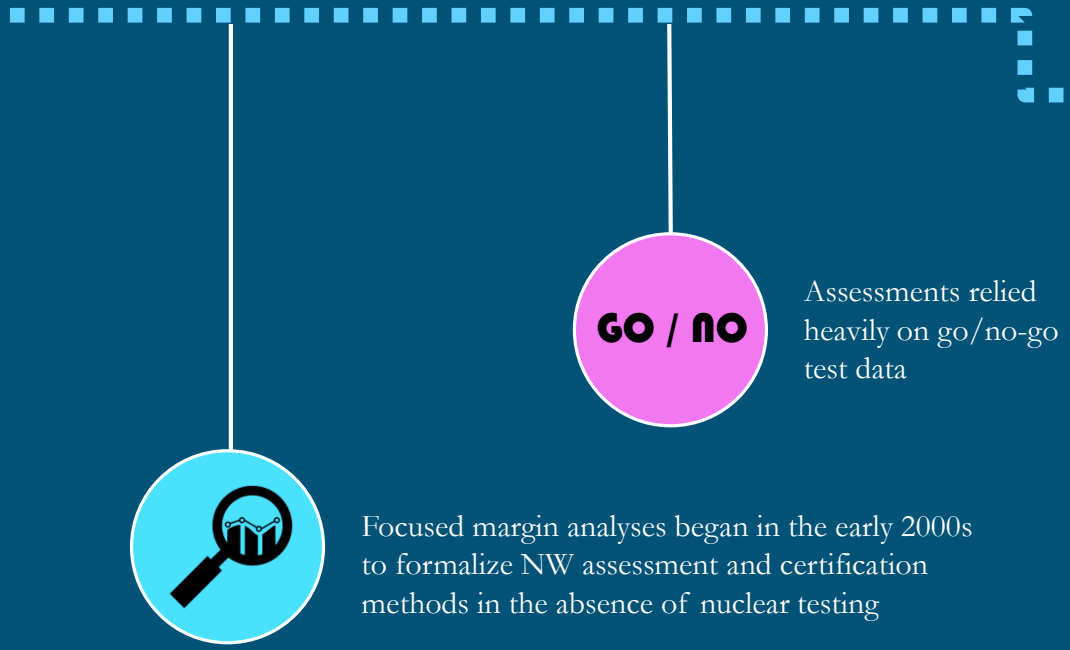
SANDIA'S JOURNEY

SME-DRIVEN

- Reliant on judgment of SMEs
- Deep engineering experience is invaluable
- Disregards valuable test data
- Expertise lost as people depart

DATA-DRIVEN

- Decisions made using data
- Broad testing abilities provide deep data
- Data lacks perspective
- Ignores the deep expertise of our colleagues



Assessments relied heavily on go/no-go test data

Focused margin analyses began in the early 2000s to formalize NW assessment and certification methods in the absence of nuclear testing

Expectations that all weapon system teams apply a data-driven framework to all major components drove automation of simplistic methods

SANDIA'S JOURNEY

SME-DRIVEN

- Reliant on judgment of SMEs
- Deep engineering experience is invaluable
- Disregards valuable test data
- Expertise lost as people depart

DATA-CENTRIC

- Statisticians and technical SMEs collaborate
- Qualitative and quantitative data used in decision making

DATA-DRIVEN

- Decisions made using data
- Broad testing abilities provide deep data
- Data lacks perspective
- Ignores the deep expertise of our colleagues

Focused margin analyses began in the early 2000s to formalize NW assessment and certification methods in the absence of nuclear testing

Assessments relied heavily on go/no-go test data

The formality and scope of analyses slowly increased over time—a statistical handbook formalizes the process

Returning to a more balanced approach combining analyses with expert knowledge

Expectations that all weapon system teams apply a data-driven framework to all major components drove automation of simplistic methods

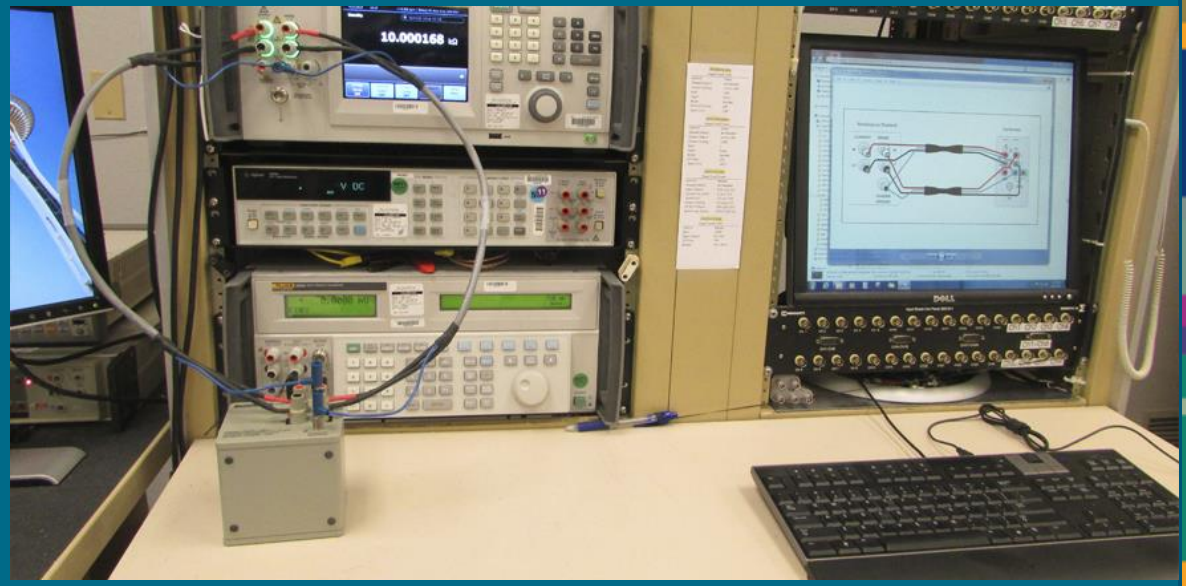
BASING DECISIONS ON BOTH DATA-DRIVEN EVIDENCE AND ENGINEERING JUDGMENT

Evidence Building Blocks	Description of Activities	
Summary statistics	• The sample size (number of units) tested • The mean and standard deviation of relevant performance parameters • The range of performance • Calculate a k-factor with 95% confidence bound	Data-driven evidence
Visualization of data	• A histogram of the performance parameter alongside the requirement	
Representativeness of units	• Were the units a representative sample of units that will be fielded? • Are changes expected production?	Engineering judgement
Representativeness of use conditions	• What changes could occur across use conditions? • What is the magnitude of measurement error?	
Anomalies	• Were there any unexpected outliers or subpopulations? • What further investigation was conducted to understand these anomalies?	
Uncertainties	• What remaining uncertainties could impact margin?	
Other Evidence	• What engineering judgment or past data are available to support a positive margin assertion?	

We apply engineering analysis that sometimes uses statistics, not vice-versa.
Good engineering judgment should always trump unvalidated statistical assumptions.

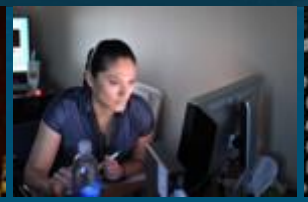
FUTURE RESEARCH THRUSTS

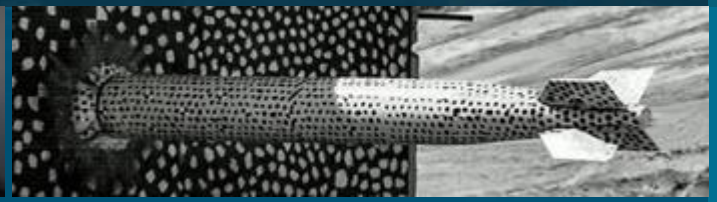
1. Data fusion for high-confidence, predictive multiphysics models
2. Data-driven statistical modeling for weapons lifecycle decision support
3. Intelligent data collection
4. Data-driven predictive aging
5. Human factors for data-informed decision analytics



Sandia National Laboratories

THANK YOU





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U.S. DEPARTMENT OF ENERGY | NNSA

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