

Innovation center, Washington, D.C.

MULTIDIMENSIONAL RISK (MRISK)

Application of Multivariate Analysis to Decision Criteria

THE SCIENCE OF TEST WORKSHOP 2017



AGENDA

MRISK

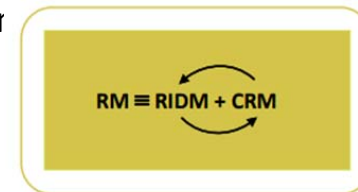
RISK MANAGEMENT OVERVIEW

SHORTCOMINGS OF LEGACY METHODS

BENEFITS OF MRISK

NASA USES TWO COMPLEMENTARY PROCESSES FOR RISK MANAGEMENT

- Risk-Informed Decision Making (RIDM)
 - Emphasizes the proper use of risk analysis to make risk-informed decisions that impact all risk dimensions including safety, technical, cost, schedule, etc...
 - Acknowledges the role that subject matter experts (SMEs) play in decisions. Emphasizes that the cumulative wisdom provided of SMEs is essential for integrating technical and nontechnical factors to produce sound decisions due to the availability of technical data and the complexity of missions
 - Source: NASA/SP-2010-576 NASA Risk-Informed Decision Making Handbook
- Continuous Risk Management (CRM)
 - To manage those risks associated with the performance levels that drove selection of a particular alternative (from RIDM)
 - A systematic and iterative process that efficiently identifies, analyzes, plans, tracks, controls, and communicates and documents risks associated with implementation of design processes
 - Source: NPR 8000.4A Agency Risk Management Procedural Requirements

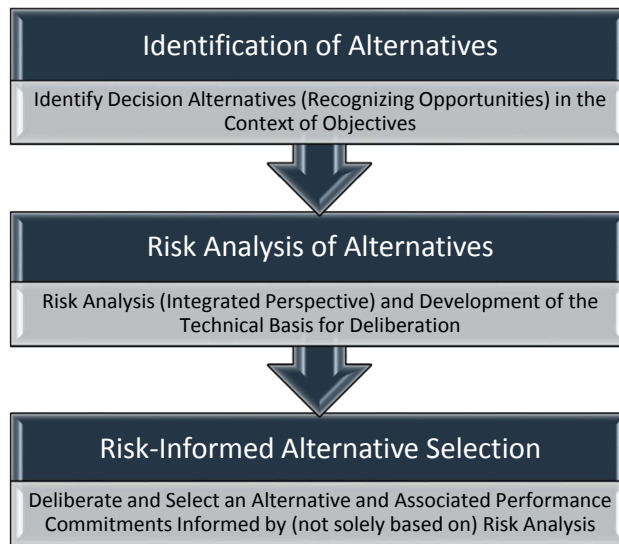


MRISK SUPPORTS BOTH RIDM AND CRM

With RIDM MRISK Can Rank Alternatives.

With CRM, MRISK Ranks Individual Risks.

Risk-Informed Decision Making (RIDM)

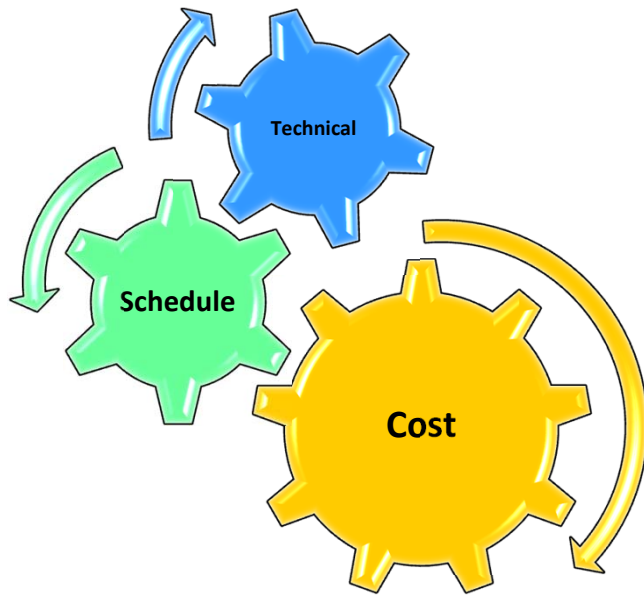


Continuous Risk Management (CRM)



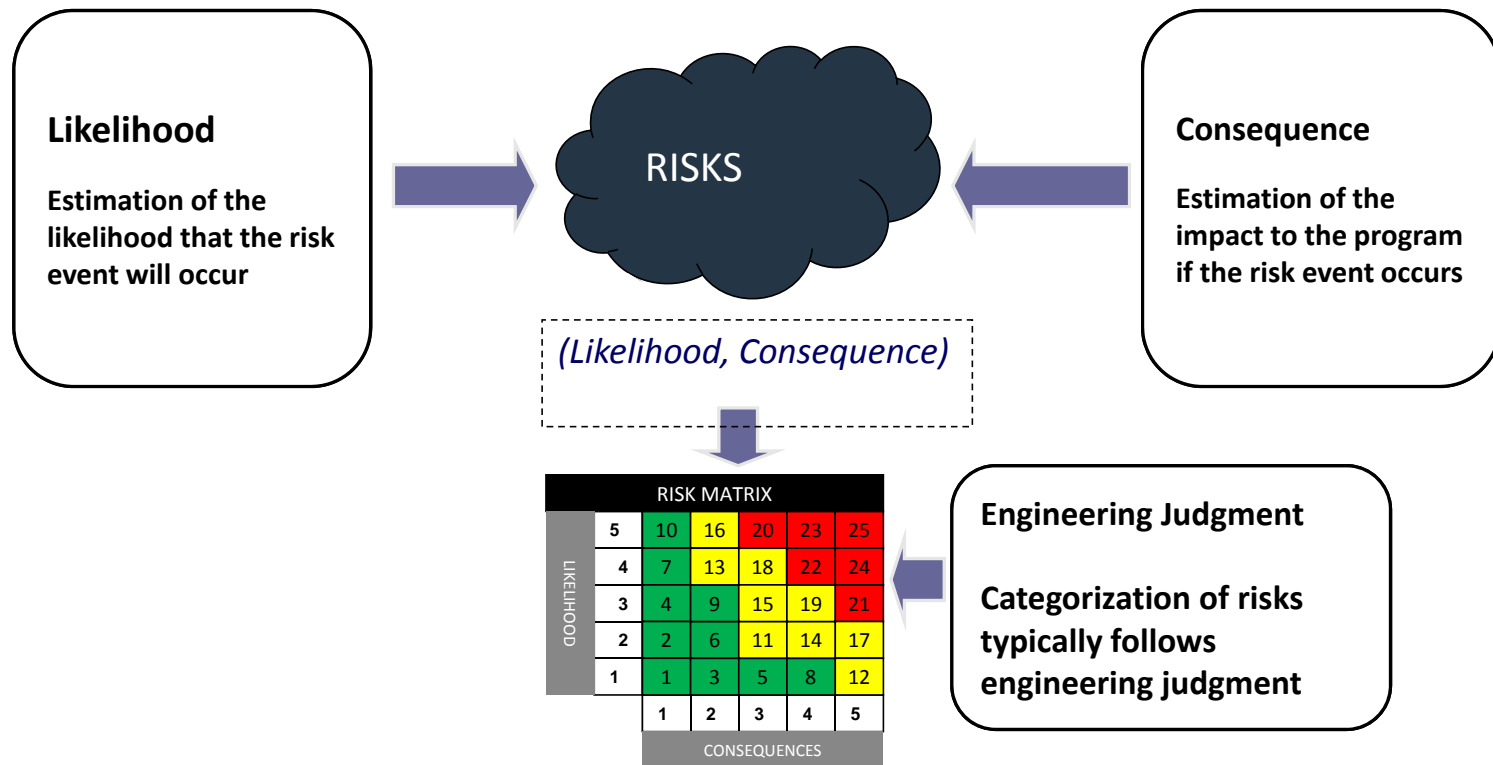
* Source: NASA/SP-2010-576 NASA Risk-Informed Decision Making Handbook

COST, SCHEDULE, & TECHNICAL RISKS TEND TO CORRELATE WITH EACH OTHER



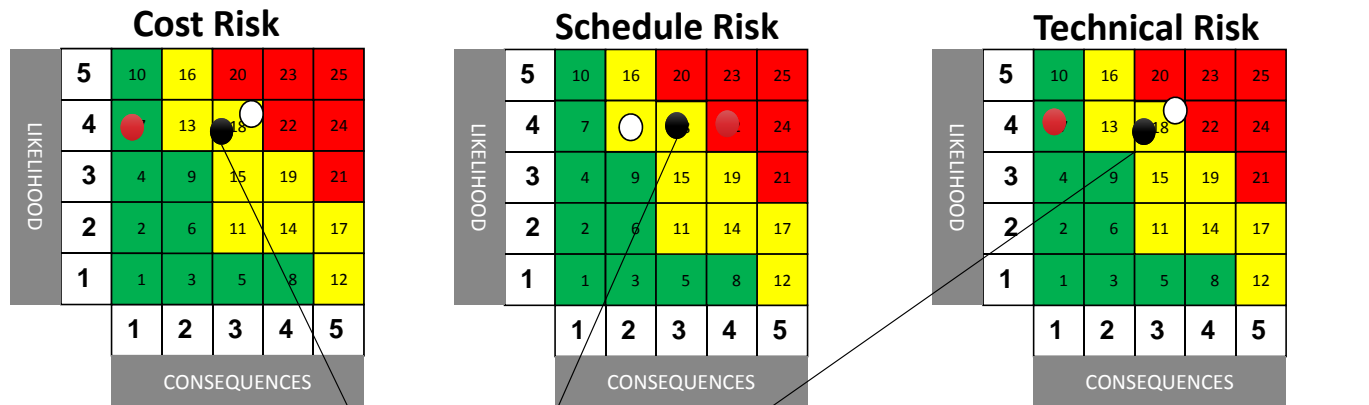
- Higher costs tend to follow schedule increases
 - Schedule decreases may create more technical risk
 - Tighter schedules tend to have greater cost risk
 - Hard technical challenges tend to take longer to execute and tend to cost more
 - A technical risk may cause schedule slips
 - Example: A facility unavailable for testing represents
 - Schedule risk due to time consequence
 - Cost risk due to schedule slip
 - Technical risk due to impact on a technical, project goal
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RISK IS TYPICALLY MEASURED AS THE ORDERED PAIR OF (LIKELIHOOD, CONSEQUENCE) = RISK



CURRENT RISK MATRIX DEVELOPMENT METHODS OFTEN FAIL TO GIVE A COMPLETE RISK PICTURE

Notional Representation Of Risks In Three Dimensions



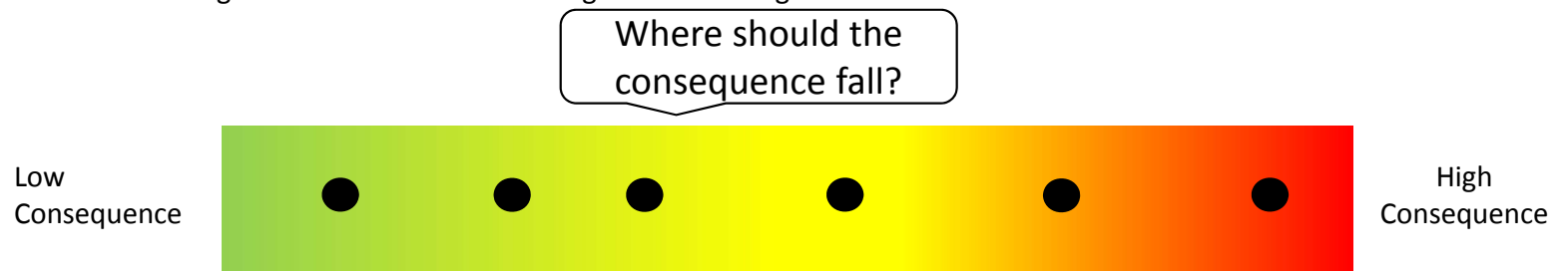
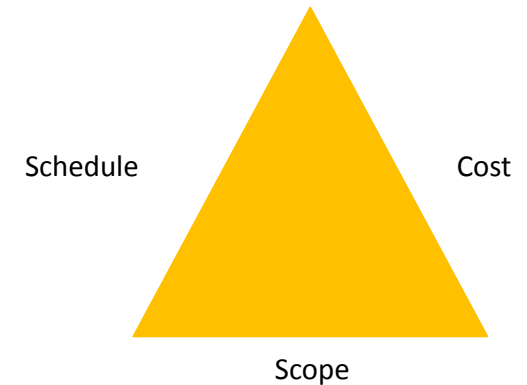
- Why are we looking at only one dimension at a time?
- Should we call pt3(3,3,3) a Cost Risk, a Schedule Risk, or a Performance Risk?
- Is pt2(1,4,1) more risky than the other points just because it has a high schedule severity?
- Is pt1(3,2,3) just as risky as pt3(3,3,3)?
- What if we have risk across four dimensions? Or five? Or Six?
- How do we know we are focusing on the right risks?

○ = pt1
● = pt2
● = pt3

MRISK PROVIDES A COMPLETE RISK PICTURE

MRISK addresses several shortcomings in the current methods

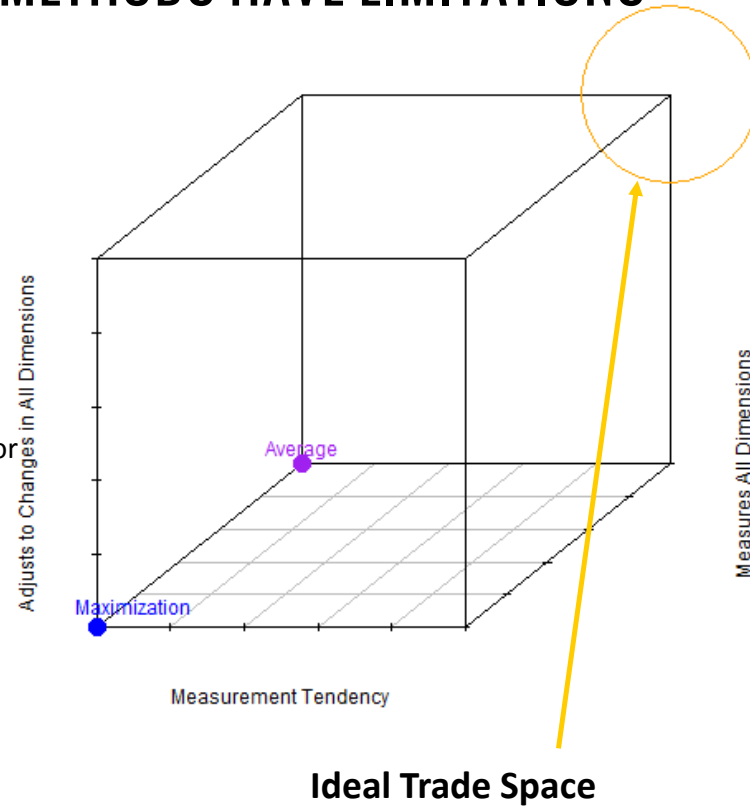
1. MRISK deals with all of the dimensions of Risk simultaneously to provide a complete risk picture
 2. MRISK makes risk analysis objective and consistent with SME judgment
 3. MRISK provides more advanced statistical algorithms to Risk Management without changing the current processes or products
- Popular methods include:
 - choosing the highest Consequence dimension (the Maximization method)
 - averaging the Consequence dimensions (the Averaging method)
 - Forcing a maximum consequence via consensus (the Root Cause method)
 - MRISK is an alternative method allow for single metric without introducing bias via forcing values to a max or the center



POPULAR METHODS HAVE LIMITATIONS

Method	Tendency	All Dimensions	Adjusts
Averaging	Yes	Yes	No
Maximization	Yes	No	No

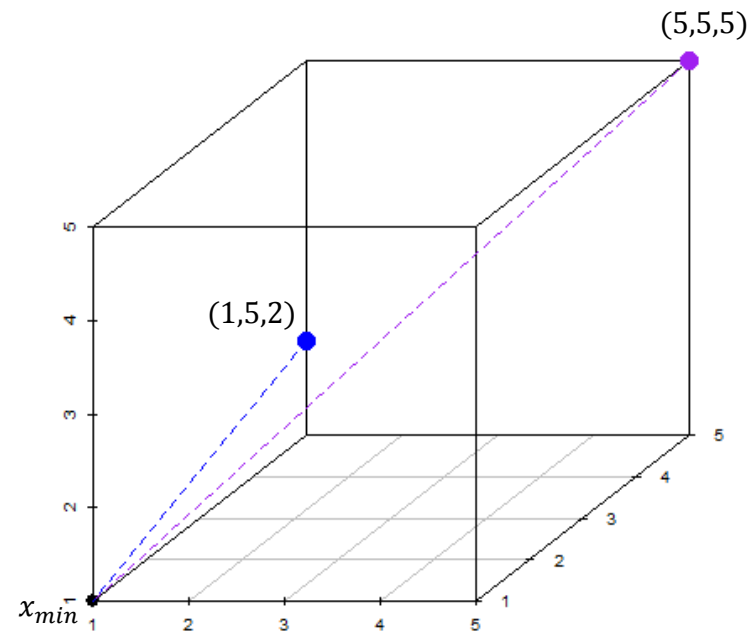
- Tendency: the method has a measurement tendency towards some portion of the scale (i.e., minimum, center, or maximum)
- All Dimensions: the method uses all the dimensions in the calculation of the metric
- Adjusts: the method adjusts to changes in all of the dimensions



Ideal Trade Space

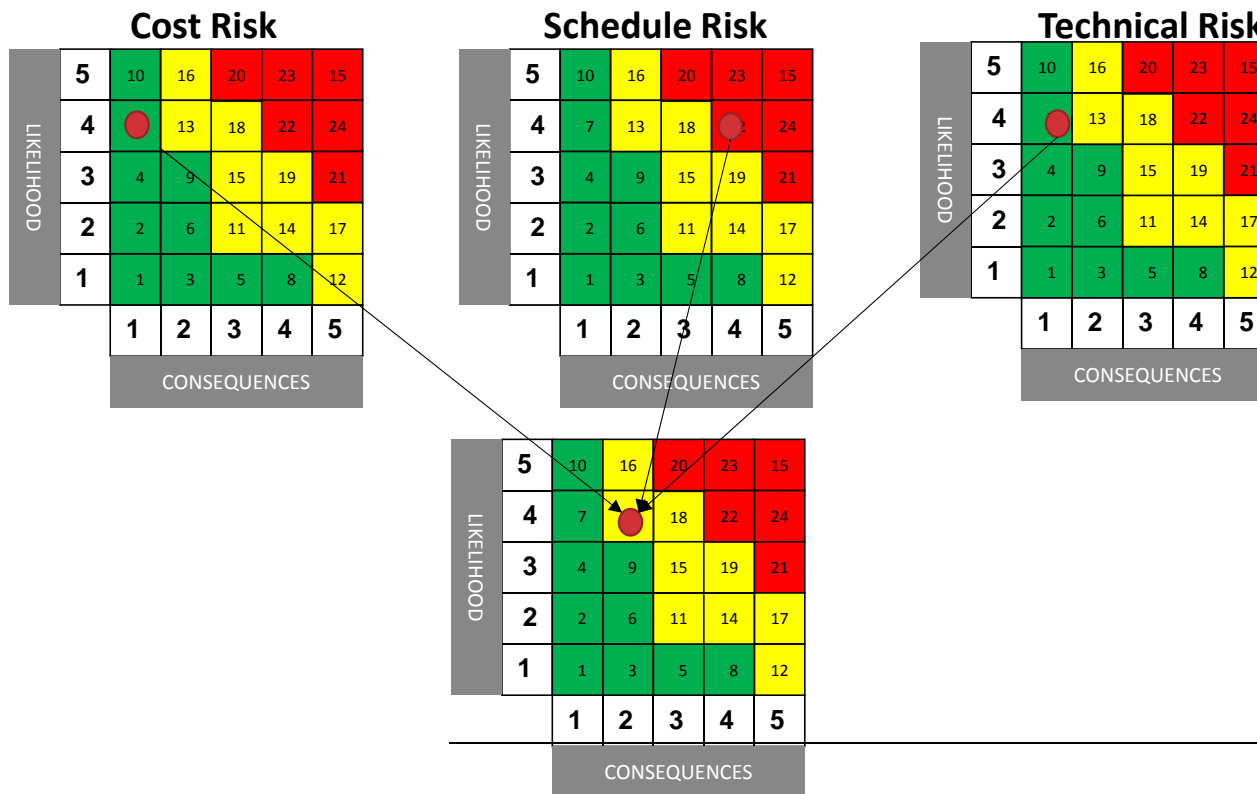
THE MAXIMIZATION METHOD ASSUMES ABSOLUTE CORRELATION

- For example, the risk rating for (1, 5, 2) is the same as (5, 5, 5)
- As the dimensions increase towards infinity, the logic of excessive conservatism falls apart
- The Maximization method maps two rather different points to the same consequence
- This lack of dispersion creates difficulty in distinguishing between critical risks



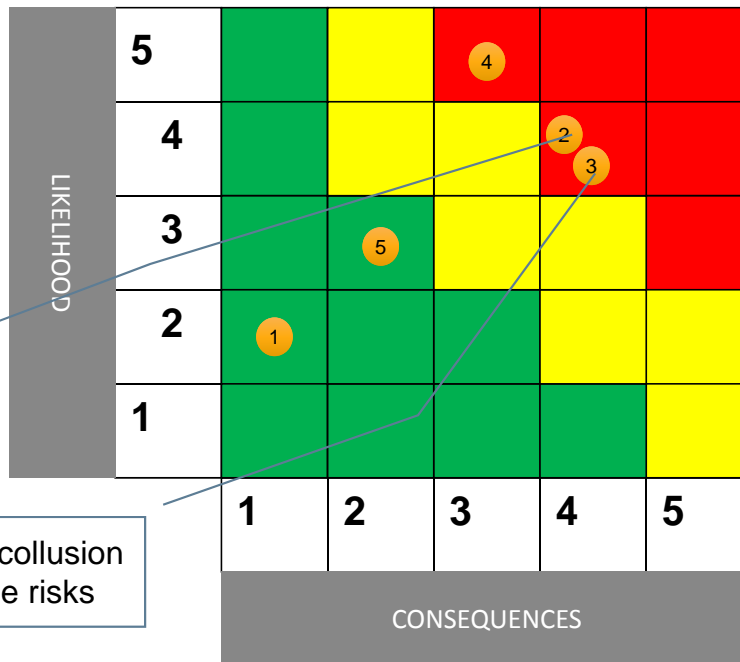
THE AVERAGE IS A UNIVARIATE PARAMETER THAT DOES NOT ACCOUNT FOR RELATIONSHIPS BETWEEN DIMENSIONS

- An average assumes independence of the Consequence dimensions
- Using the average, some risks may be deflated or inflated towards the middle



EUCLIDEAN DISTANCE DOES NOT CONSIDER RELATIONSHIPS

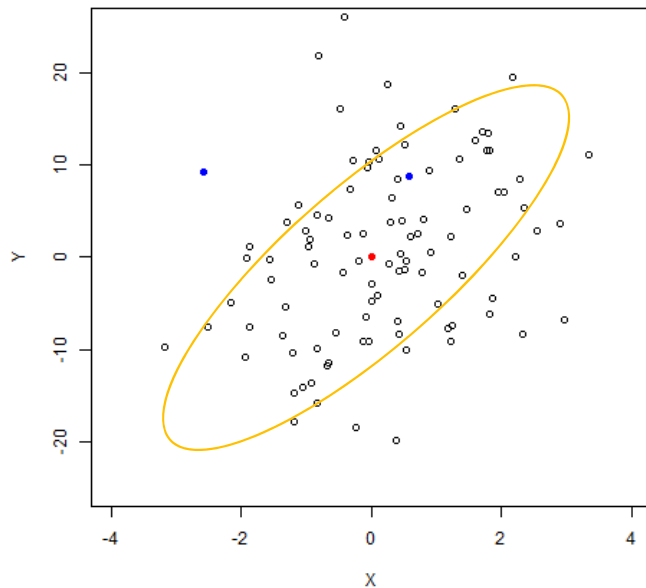
RiskID	Like	Cost	Schd	Tech	Euclidean
1	2	1	2	1	1.1
2	4	4	4	3	4.1
3	4	4	3	5	4.4
4	5	5	1	3	3.0
5	3	4	2	1	2.1



Lumping on severity despite differences

Possible collusion of extreme risks

MRISK TAKES ADVANTAGE OF MAHALANOBIS DISTANCE'S ASSETS

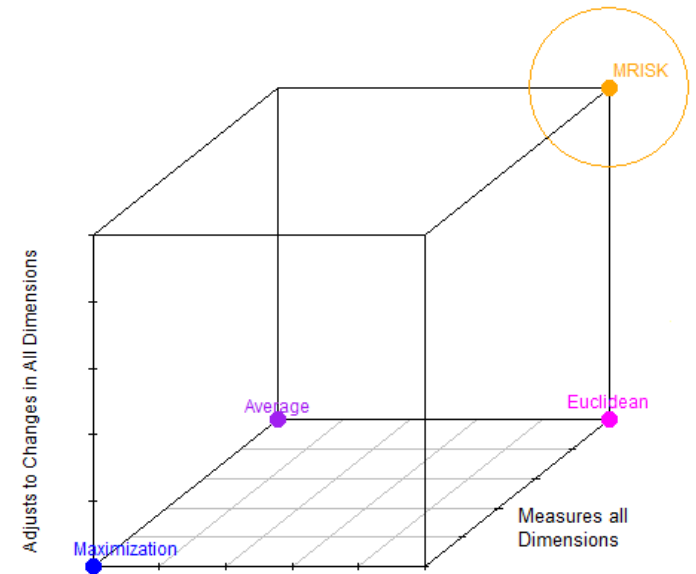


Blue points have approximately the same Mahalanobis distance to the center in red

- Mahalanobis distance is a generalized distance for multiple dimensions that measures how many standard deviations a vector is away from a distribution
 - The three primary advantages of using Mahalanobis distance are:
 - Accounting for correlation between variables
 - Reverting to normalized Euclidean distance when correlation does not exist or when vectors occupy the same plane
 - The ability to scale to infinite dimensions. In other words, the procedure will never lose validity as the dimensions grow
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MRISK DEALS WITH SEVERAL SHORTCOMINGS IN LEGACY RISK ANALYSIS

- MRISK uses Engineering Judgment to help decision makers get a full picture of the risk portfolio
- Just because we cannot visualize risk in multiple dimensions doesn't mean the dimensions don't exist. We all realize that Risk Management is a multi-dimensional problem. MRISK is a multi-dimensional solution to this problem.
- MRISK does not seek to change Risk Management from its current practices and procedures. It just revolutionizes Risk Analysis.
- MRISK does not require any change to current data collection techniques for implementation
- MRISK takes the data from the current risk methods and allows for interpretation of risks through a multidimensional lens
- The use of Mahalanobis Distance as a measure of consequence takes into account the relationships that risk events have across dimensions
 - Since we know cost relates to schedule, schedule relates to performance, performance relates to safety, etc... MRISK is most appropriate for measuring risk as it emphasizes the relationships among risks to calculate distance



Method	Tendency	All Dimensions	Adjusts
Averaging	Yes	Yes	No
Maximization	Yes	No	No
Euclidean	No	Yes	No
MRISK	No	Yes	Yes