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A Fresh Look at Risk in S&T
A Systems Engineering Approach

Tom Archer, Carol Ventresca, Bryan DeHoff, SynGenics
AFRL/RX Systems Engineering Team
Bob Rapson, Bob Enghauser, Bill Kesling, AFRL/RX
Gerry Hasen, Universal Technology Corporation

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Abstract

In S&T, the word ***risk*** carries connotations of uncertainty, fear, and the likelihood of wasted time and effort. The conservative S&T manager may conclude that no “risky” project is worth doing. This paper argues for accomplishing more effective S&T through more accurate recognition and thorough addressing of risk at both the technical and strategic levels.

Risk is easily trivialized when it is described as a schedule slippage or cost overrun. These are simply causes for far more dramatic disasters in S&T. There is an implicit assumption that greater risk leads to greater rewards. While it is an appealing premise that may apply in lotteries and casinos for recreation, it has no place in S&T. Instead, it is a problematic assumption that helps to rationalize casual risk management practices.

The briefing challenges the often-stated axiom that S&T is inherently *the business of risk*. Professional S&T management is the business of eliminating risk, both within S&T and for the S&T mission.

The true *risks*, or more accurately, failure modes, in S&T are often unrecognized or ignored. In fact, risk is generally well managed when explicitly recognized. In some cases, the S&T objective is to characterize risk. Risk has three components: a definition, a probability of occurrence, and an undesirable consequence. In S&T, the definitions are often misstated, the probabilities are rarely known, and the consequences are regularly trivialized. So what is usually described as risk is more accurately *uncertainty*. Using the elements of risk, recognizing that they need to be applied with mathematical precision in an environment of uncertainty, leads to developing more effective S&T.

This briefing captures the current state of risk recognition and management in a typical S&T environment: it proposes an approach that is more focused on the end user and that attains the rigor and precision necessary to manage elements of risk to enhance the outcomes of S&T efforts.

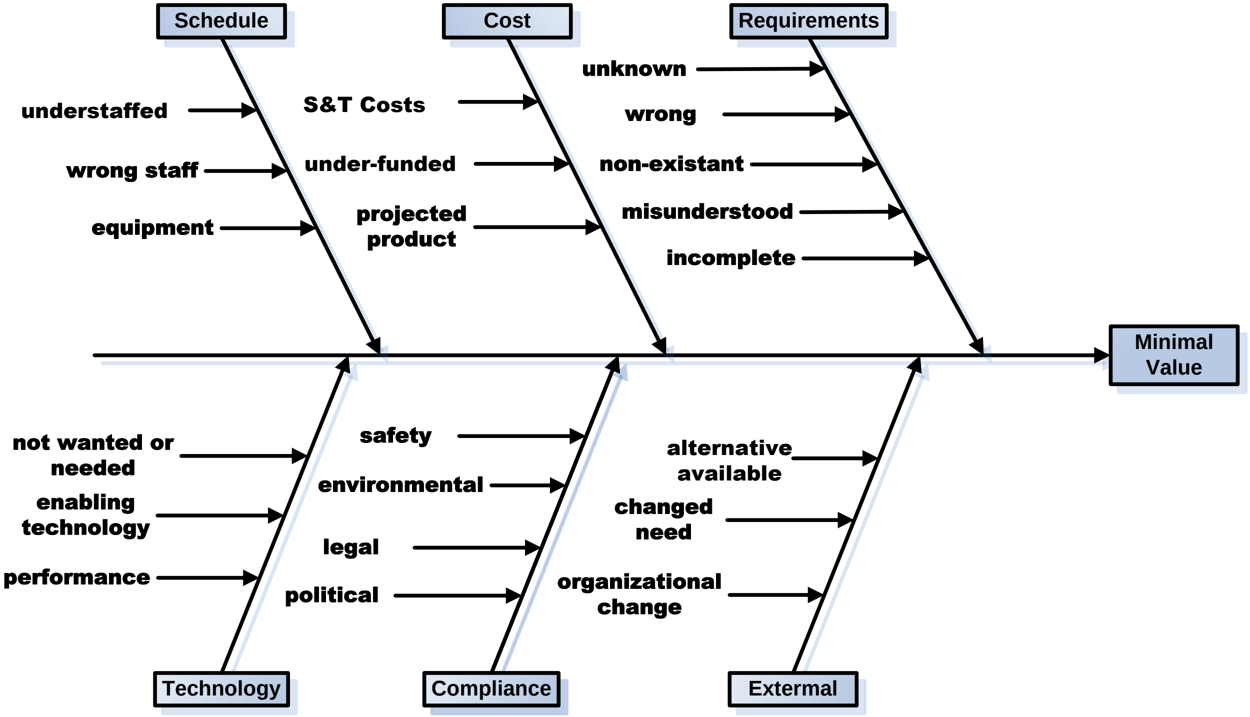
Outline

- Overview
- Risk in S&T
- Elements of Risk and Consequences
- Assessing and Managing Risk in S&T, the Systems Engineering Approach
- Discussion

Risk in Science & Technology (S&T) Is Problematic

- *Risk* is about the unknowns and un-knowables.
- S&T is about the future; everything we *know* about *risk* is in the past.
- S&T can be inherently low risk, or the S&T professional can embrace risk with user focus.
- Risk in S&T exists at the technical level and the executive (strategic) level.
  - The typical focus is on programmatic elements at the technical level

Greatest Risk in S&T Today, Work Has Minimal Value



Schedule
understaffed
wrong staff
equipment

Cost
S&T Costs
under-funded
projected product

Requirements
unknown
wrong
non-existant
misunderstood
incomplete

Technology
not wanted or needed
enabling technology
performance

Compliance
safety
environmental
legal
political

External
alternative available
changed need
organizational change

Minimal Value

- ➢ Unwanted
- ➢ Unresponsive
- ➢ Prohibitively expensive
- ➢ Not conceived in a systems context
- ➢ Too late, overcome by events or commercial product

S&T Risk Exposure Areas

- **Executive level**
  - – Failure to properly fund the “right” S&T
  - – Failure to resource it in a timely manner

- **Technical level**
  - – Selecting the best technical approach(es),
    ….with all that “best” means
  - – Program planning
  - – Program execution

Risk in Common Usage

- **Something is *risky* if there is an expectation or belief that there is more than a remote possibility the outcome will be bad.**
  - “Texting while driving greatly increases the *risk* of being injured or killed in a motor vehicle crash.”
  - “The annual *risk* of being killed in a plane crash for the average American is about 1 in 11 million.”
  - Flying on a commercial flight in good weather is not considered risky; driving while intoxicated is.

We have a useful common-sense notion of risk

Risk in a Professional Context

- “…gaps in the utility’s gas system records, upkeep, and emergency response plan created an ‘unacceptable *risk*’ of a disaster….”

Unclear

- Guaranteed a “100% probability of failure within 24 months of installation”

Clear

- “Buffett’s bet on BofA [Bank of America] may be among his riskiest.”

Inaccurate

Risk in a professional context needs clarity and mutual understanding

Risk in S&T

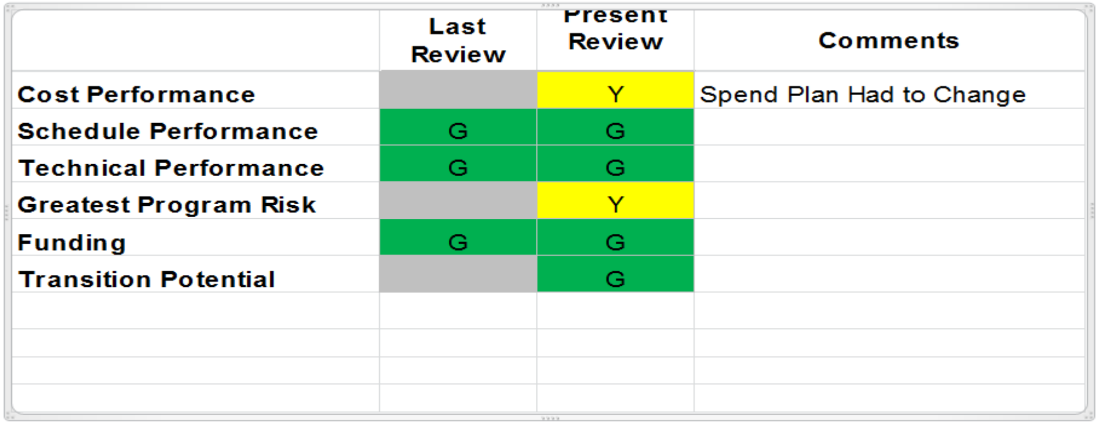
“Mistaken assumptions about airflow over the U.S. DARPA’s Lockheed Martin HTV-2 hypersonic glider are believed to have resulted in the early termination of its first flight on April 22, 2010.…Investigators discovered a stronger-than-expected coupling between vehicle yaw and roll.…Extensive post-mishap hypersonic wind tunnel testing improved designers’ understanding of the phenomenon, but failed to remove all question marks about when the transition would occur.”

Beyond the safety aspects, the HTV-2 was not *risky*; it was a planned experiment with minimum negative consequences and the results, though not desired, were not unexpected.

The notional thought about risk in S&T tends to focus on the objective science and the technology.

Warwick, Graham, Uncertain Flight: HTV-2 Being Modified To Cope With Hypersonic Unknowns, Aviation Week, August 01, 2011, p 14.

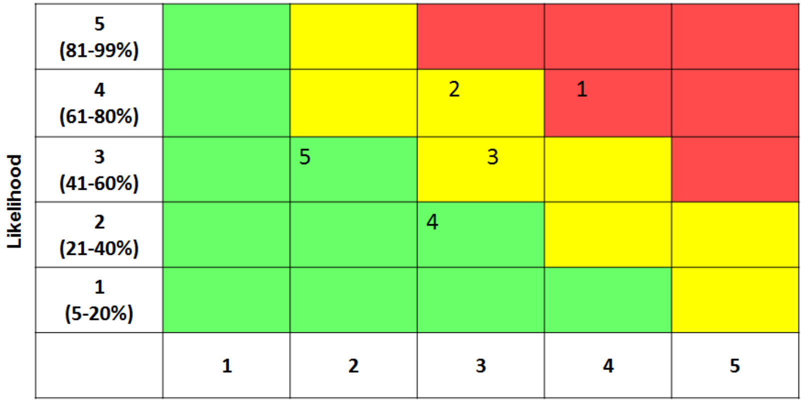
Example – Typical S&T Risk Chart



	Last Review	Present Review	Comments
Cost Performance		Y	Spend Plan Had to Change
Schedule Performance	G	G	
Technical Performance	G	G	
Greatest Program Risk		Y	
Funding	G	G	
Transition Potential		G	

Risk Mitigation Plans:

- Cost Performance Listed as Yellow due to Program changes, including new PM. Expenditure rates are being reviewed and will be accelerated.



Likelihood					
5 (81-99%)	🟩	🟨	🟥	🟥	🟥
4 (61-80%)	🟩	🟨	🟨 2	🟥 1	🟥
3 (41-60%)	🟩	🟩 5	🟨 3	🟨	🟥
2 (21-40%)	🟩	🟩	🟩 4	🟨	🟨
1 (5-20%)	🟩	🟩	🟩	🟩	🟨
	1	2	3	4	5

Consequence

1– Successful Fiber Combination
2– Slab Quality (materials issues)
3-- Beam Quality (Adaptive Optics)
4-- Contain Cost overruns to 10%
5-- Meet customers aggressive schedule requirements

Ref: AFPAM 63-128, "Guide to Acquisition and Sustainment Life Cycle Management" (5 Oct 2009)

Category	Risk Level
Protection Option 1	🟥
Protection Option 2	🟧
Internal Option 1	🟨
Internal Option 2	🟧
Integrated Solution	🟥
Damage Protection 1	🟧
Damage Protection 2	🟨

Risk and Uncertainty

Risk, as commonly used in the S&T community, is more accurately ***uncertainty***.

Risk is the appropriate term when two conditions are met:

1. The probability of an event occurring can be accurately estimated or is known, usually based upon a large data set concerning similar events in the past with a known distribution of outcomes and the assumption is made that the future mirrors the past.
2. A large number of similar events are part of the future candidate universe and the risk concern is with the events in aggregate, not with a particular event.

With a few exceptions, neither condition is met in S&T

Therefore, the risk tools so widely used in fields like insurance, banking, investment and even life cycle maintenance must be applied carefully, modified or abandoned in favor of more effective approaches.

Consequences Not Semantics
The Elements of Risk

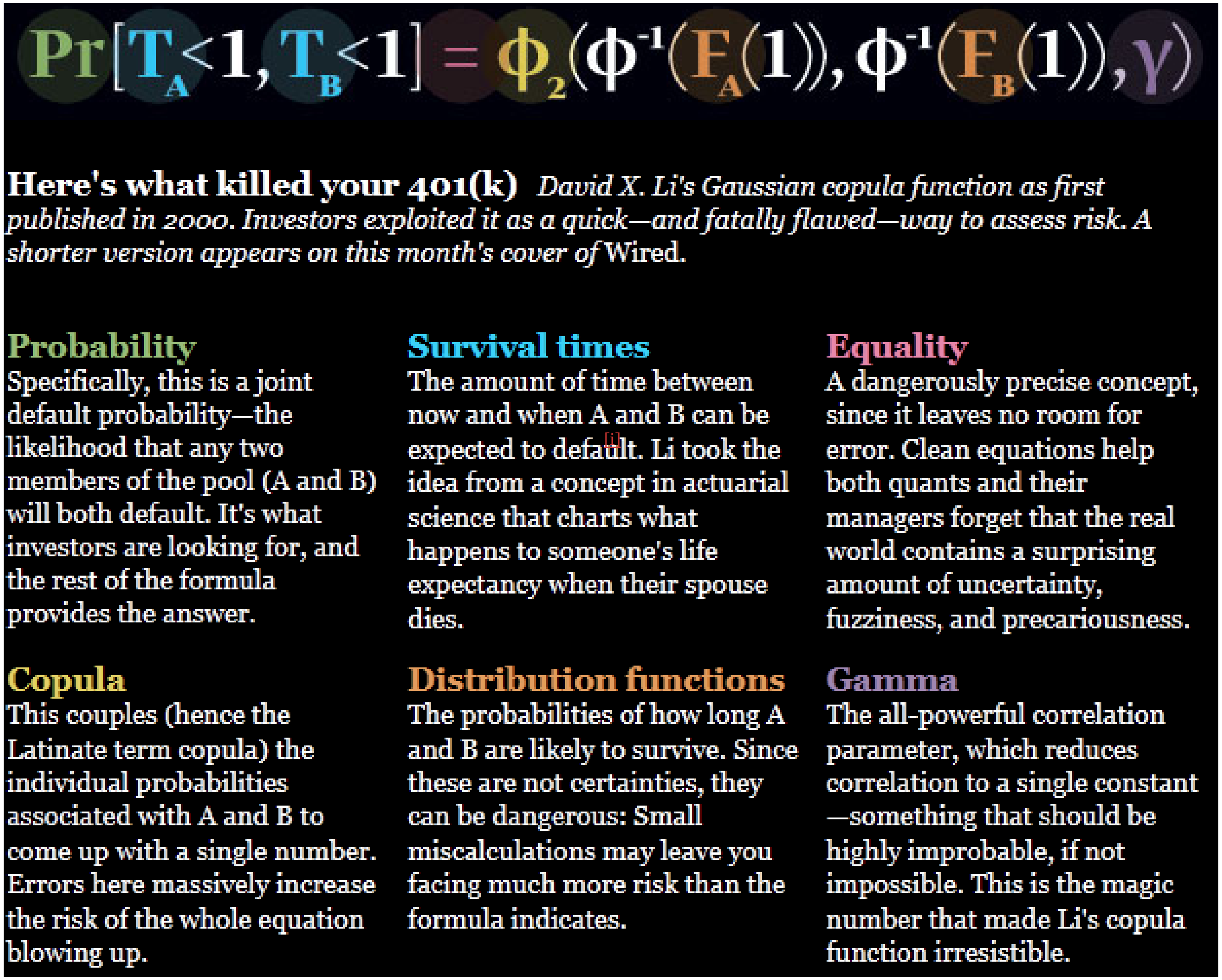
Risk, to a purist in a professional context, has three elements:

- A description of the risk or risk event
- A known or expected probability of occurrence; rarely, if ever known in S&T
- A significant consequence

Uncertainty is the state of not knowing whether something is true or false, whether it will or will not happen. In *S&T* the absence of a probability distribution for the occurrence of an event creates uncertainty rather than risk, at least to a purist. Still, the convention is to call the situation *risk*.

Casual S&T convention is to use *risk* and *uncertainty* interchangeably, the issue is consequences, not semantics.

Risk that the Risk Model is Wrong



$$\Pr[T_A<1, T_B<1] = \phi_2(\phi^{-1}(F_A(1)), \phi^{-1}(F_B(1)), \gamma)$$

Here's what killed your 401(k) *David X. Li's Gaussian copula function as first published in 2000. Investors exploited it as a quick—and fatally flawed—way to assess risk. A shorter version appears on this month's cover of* Wired.

Probability
Specifically, this is a joint default probability—the likelihood that any two members of the pool (A and B) will both default. It's what investors are looking for, and the rest of the formula provides the answer.

Copula
This couples (hence the Latinate term copula) the individual probabilities associated with A and B to come up with a single number. Errors here massively increase the risk of the whole equation blowing up.

Survival times
The amount of time between now and when A and B can be expected to default. Li took the idea from a concept in actuarial science that charts what happens to someone's life expectancy when their spouse dies.

Distribution functions
The probabilities of how long A and B are likely to survive. Since these are not certainties, they can be dangerous: Small miscalculations may leave you facing much more risk than the formula indicates.

Equality
A dangerously precise concept, since it leaves no room for error. Clean equations help both quants and their managers forget that the real world contains a surprising amount of uncertainty, fuzziness, and precariousness.

Gamma
The all-powerful correlation parameter, which reduces correlation to a single constant—something that should be highly improbable, if not impossible. This is the magic number that made Li's copula function irresistible.

Felix Salmon, "Recipe for Disaster: The Formula That Killed Wall Street," *Wired Magazine* (February, 2009).

Proposed Working Definition of Risk in S&T

***Risk** (in an S&T effort) –*
*An event that can result in a significant negative consequence **outside** the S&T effort or organization.*

It is the prospect of significant external consequences that creates internal risk; and the corollary is that failure may create internal consequences.

Problems with the Working Definition

- ***Significant*** is a qualitative term, in this context. It is more clearly defined in the risk assessment and mitigation phase.

- The possibility of ***negative consequences outside the organization*** changes the focus from traditional technical and programmatic elements.

- The S&T world is ***dynamic***. Priorities change, sometimes quickly and dramatically.

Summarizing Risk Elements and Consequences

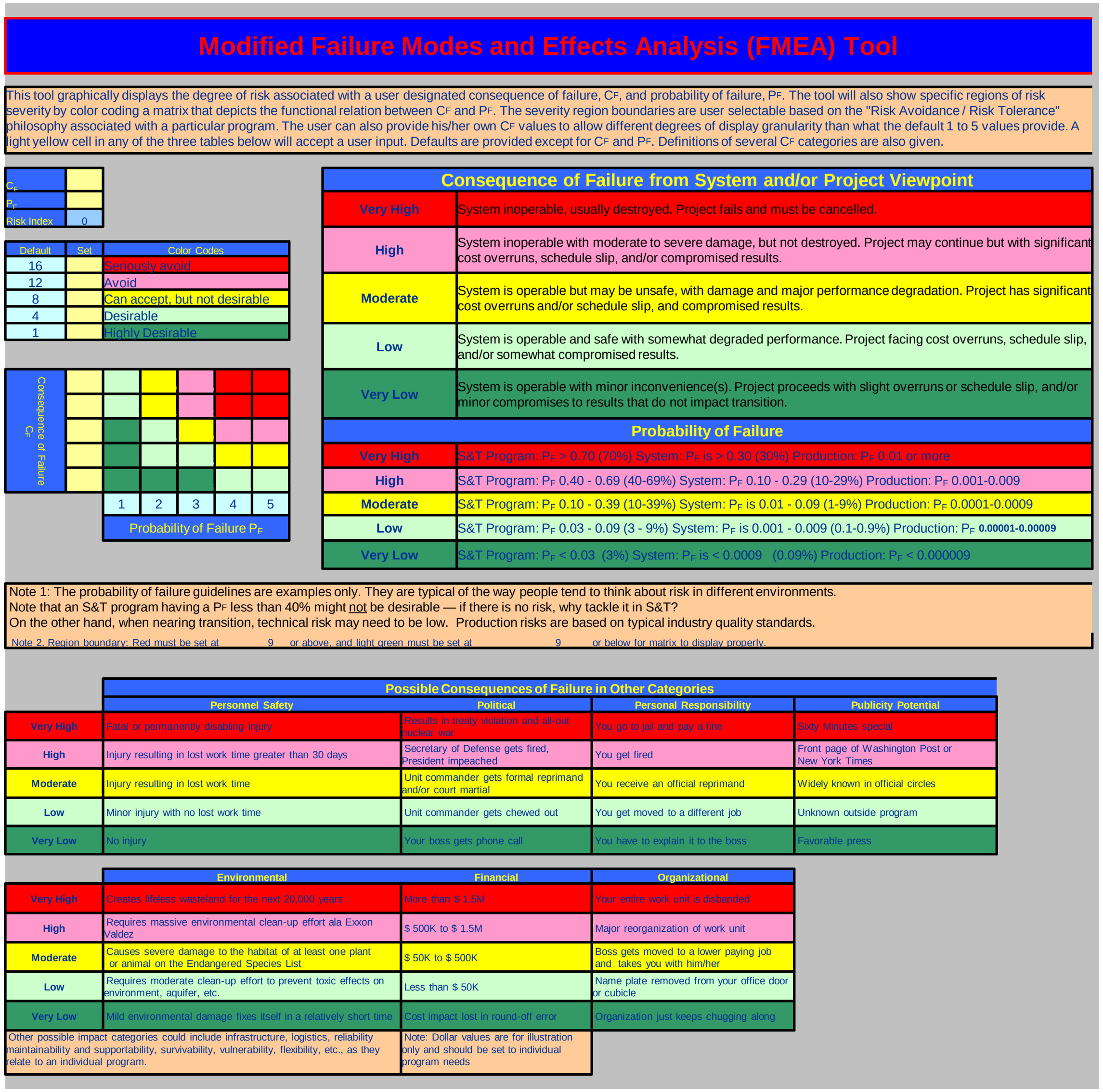
- ***Risk in S&T*** is an event in an S&T effort that can result in a significant negative consequence ***outside*** the S&T effort or organization.
- Risk is not an inherent measure of significance or importance. S&T efforts may be potentially “disruptive” or “game changing” but not *risky* until the consequences of failure are understood and valued.
- In S&T, the probabilities that a risk event will occur are unknown; so risk approaches and tools have to be adapted.

Assessing and Managing Risks Under Uncertainty

- **Straightforward in concept:**
  - Identify and define the risks and consequences *to the degree possible*
  - Assess the risks, focusing on consequences
  - Monitor the situation; iterate as appropriate
  - Manage the risk; mitigate if appropriate

- **Difficult in execution**
  - S&T environment evolves, internally and externally
  - Consequences can be difficult to identify, more difficult to anticipate
  - People will not agree

Example: Stakeholder Risk-Consequence Matrix



Modified Failure Modes and Effects Analysis (FMEA) Tool

This tool graphically displays the degree of risk associated with a user designated consequence of failure, C_F, and probability of failure, P_F. The tool will also show specific regions of risk severity by color coding a matrix that depicts the functional relation between C_F and P_F. The severity region boundaries are user selectable based on the "Risk Avoidance / Risk Tolerance" philosophy associated with a particular program. The user can also provide his/her own C_F values to allow different degrees of display granularity than what the default 1 to 5 values provide. A light yellow cell in any of the three tables below will accept a user input. Defaults are provided except for C_F and P_F. Definitions of several C_F categories are also given.

C_F	
P_F	
Risk Index	0

Default	Set	Color Codes
16		Seriously avoid
12		Avoid
8		Can accept, but not desirable
4		Desirable
1		Highly Desirable

Consequence of Failure C_F						
		🟩	🟨	🟪	🟥	🟥
		🟩	🟨	🟪	🟥	🟥
		⬛	🟩	🟨	🟪	🟪
		⬛	🟩	🟩	🟨	🟨
		⬛	⬛	⬛	🟩	🟩
		1	2	3	4	5
		Probability of Failure P_F				

Consequence of Failure from System and/or Project Viewpoint	
Very High	System inoperable, usually destroyed. Project fails and must be cancelled.
High	System inoperable with moderate to severe damage, but not destroyed. Project may continue but with significant cost overruns, schedule slip, and/or compromised results.
Moderate	System is operable but may be unsafe, with damage and major performance degradation. Project has significant cost overruns and/or schedule slip, and compromised results.
Low	System is operable and safe with somewhat degraded performance. Project facing cost overruns, schedule slip, and/or somewhat compromised results.
Very Low	System is operable with minor inconvenience(s). Project proceeds with slight overruns or schedule slip, and/or minor compromises to results that do not impact transition.

Probability of Failure	
Very High	S&T Program: $P_F > 0.70$ (70%) System: P_F is > 0.30 (30%) Production: P_F 0.01 or more
High	S&T Program: P_F 0.40 - 0.69 (40-69%) System: P_F 0.10 - 0.29 (10-29%) Production: P_F 0.001-0.009
Moderate	S&T Program: P_F 0.10 - 0.39 (10-39%) System: P_F is 0.01 - 0.09 (1-9%) Production: P_F 0.0001-0.0009
Low	S&T Program: P_F 0.03 - 0.09 (3 - 9%) System: P_F is 0.001 - 0.009 (0.1-0.9%) Production: P_F 0.00001-0.00009
Very Low	S&T Program: $P_F < 0.03$ (3%) System: P_F is < 0.0009 (0.09%) Production: $P_F < 0.000009$

Note 1: The probability of failure guidelines are examples only. They are typical of the way people tend to think about risk in different environments.
Note that an S&T program having a P_F less than 40% might not be desirable — if there is no risk, why tackle it in S&T?
On the other hand, when nearing transition, technical risk may need to be low. Production risks are based on typical industry quality standards.

Note 2. Region boundary: Red must be set at 9 or above, and light green must be set at 9 or below for matrix to display properly.

Possible Consequences of Failure in Other Categories	Personnel Safety	Political	Personal Responsibility	Publicity Potential
Very High	Fatal or permanently disabling injury	Results in treaty violation and all-out nuclear war	You go to jail and pay a fine	Sixty Minutes special
High	Injury resulting in lost work time greater than 30 days	Secretary of Defense gets fired, President impeached	You get fired	Front page of Washington Post or New York Times
Moderate	Injury resulting in lost work time	Unit commander gets formal reprimand and/or court martial	You receive an official reprimand	Widely known in official circles
Low	Minor injury with no lost work time	Unit commander gets chewed out	You get moved to a different job	Unknown outside program
Very Low	No injury	Your boss gets phone call	You have to explain it to the boss	Favorable press

	Environmental	Financial	Organizational
Very High	Creates lifeless wasteland for the next 20,000 years	More than $ 1.5M	Your entire work unit is disbanded
High	Requires massive environmental clean-up effort ala Exxon Valdez	$ 500K to $ 1.5M	Major reorganization of work unit
Moderate	Causes severe damage to the habitat of at least one plant or animal on the Endangered Species List	$ 50K to $ 500K	Boss gets moved to a lower paying job and takes you with him/her
Low	Requires moderate clean-up effort to prevent toxic effects on environment, aquifer, etc.	Less than $ 50K	Name plate removed from your office door or cubicle
Very Low	Mild environmental damage fixes itself in a relatively short time	Cost impact lost in round-off error	Organization just keeps chugging along
Other possible impact categories could include infrastructure, logistics, reliability maintainability and supportability, survivability, vulnerability, flexibility, etc., as they relate to an individual program.		Note: Dollar values are for illustration only and should be set to individual program needs	

‘Consequences’ are to outside stakeholders, not to the program or project elements.

AFRL FMEA Tool (unpublished)
William L. Nolte, AFRL/XPQ

S&T Streamlined Systems Engineering Approach to Risk

	Step 1	Step 2	Step 3	Step 4	Step 5
	Define Objective	***Determine Requirements***	***ID Success Components (Alternatives)***	***Probabilistic Risk Assessment***	***Risk Mitigation Plan***
Do:	• Define Problem at the appropriate level, may be project or may be system level	• Define Requirements • Define Tech Challenges • Define S&T Exit Criteria (KPP sets) • Validate with customer	• ID what must happen to successfully meet requirements	• Estimate from history, or calculate the probability distribution using standard techniques	• Define the risk areas to be mitigated • Prepare for intended action course
Document:	❑ Problem Definition	❑ Prioritized Requirement Set - Performance - Affordability - Producibility - Reliability - Supportability ❑ S&T Exit Criteria	❑ Alternative Definitions	❑ Risk probability distributions and methods of developing ❑ Results of assessment	❑ Risk mitigation plan

Based on S&T IPPD Process (Version 3, 2002)

S&T Streamlined Systems Engineering Approach to Risk

1. ***Define the desirement(s)*** *(What do you want?)*
2. ***Identify alternative(s)***, the technologies with potential to satisfy the *desirements*
3. ***Score the alternative(s)***: the best estimate of how well an alternative will meet the desirement
4. Estimate a probability distribution
5. Perform a sensitivity analysis
6. Focus on the highly leveraged (most sensitive) issues
7. Generate a probabilistic risk profile
   - Monitor and change as more information is available

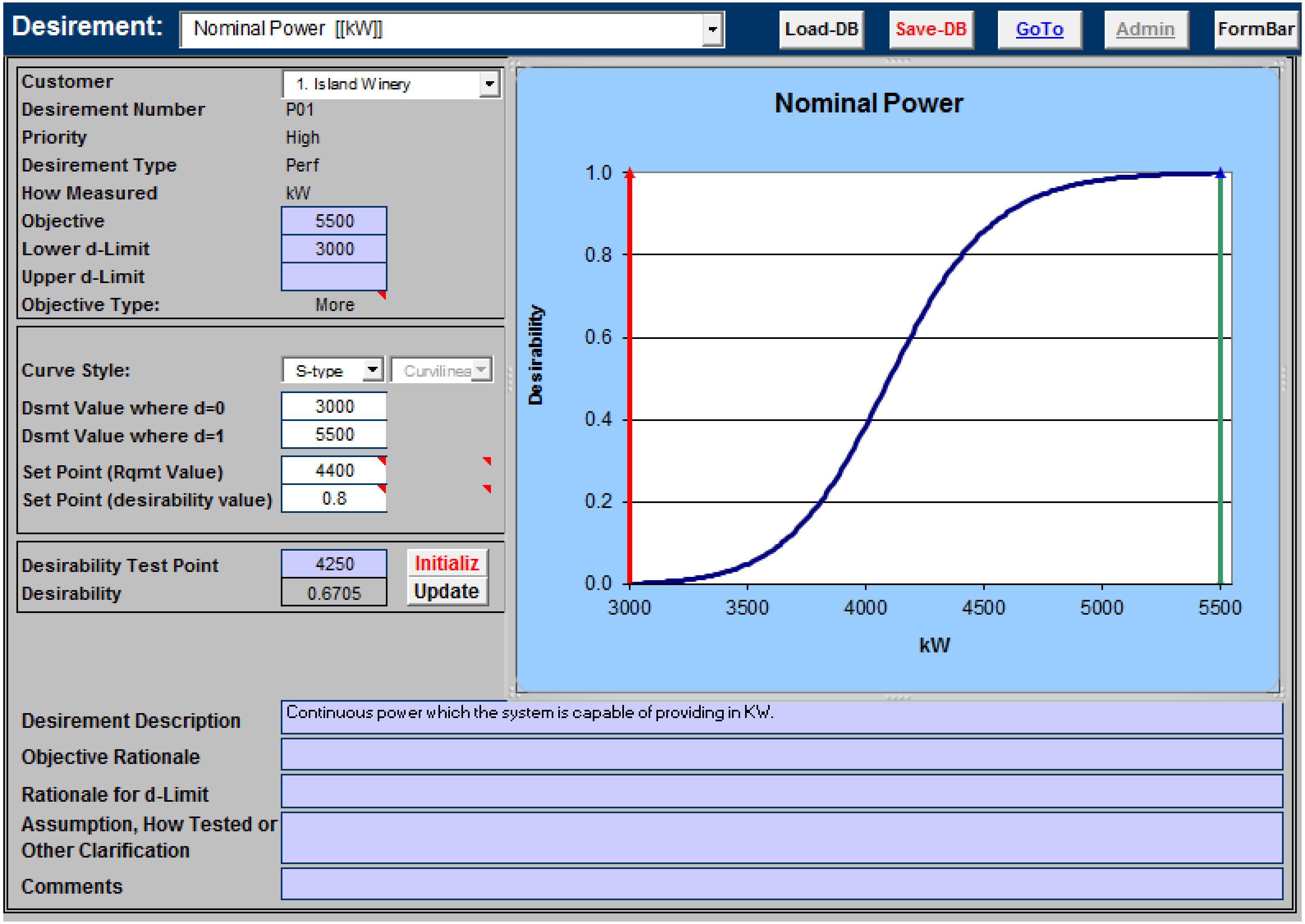
S&T Streamlined Systems Engineering Approach to Risk – Determine *Requirements*

- No "requirements" in the acquisition sense; *desirements* that may evolve in pre-acquisition.
- *Desirements* are the starting point for identifying risks:
  - What is the S&T output intended to accomplish?
  - Why is it better than the alternatives, including nothing?
  - When will it be available; when needed?
  - How will it do that and in what context (part of a system)? Is anything else needed?
  - Who will make it happen and who will want it?
  - How much to develop and how much will it cost as delivered?

Every S&T *risk* is associated with an S&T *desirement.*
If there is no *desirement*, there is no *risk*.

Risk requires an external consequence. S&T risk has a desirement and a consequence for failing to achieve that desirement.

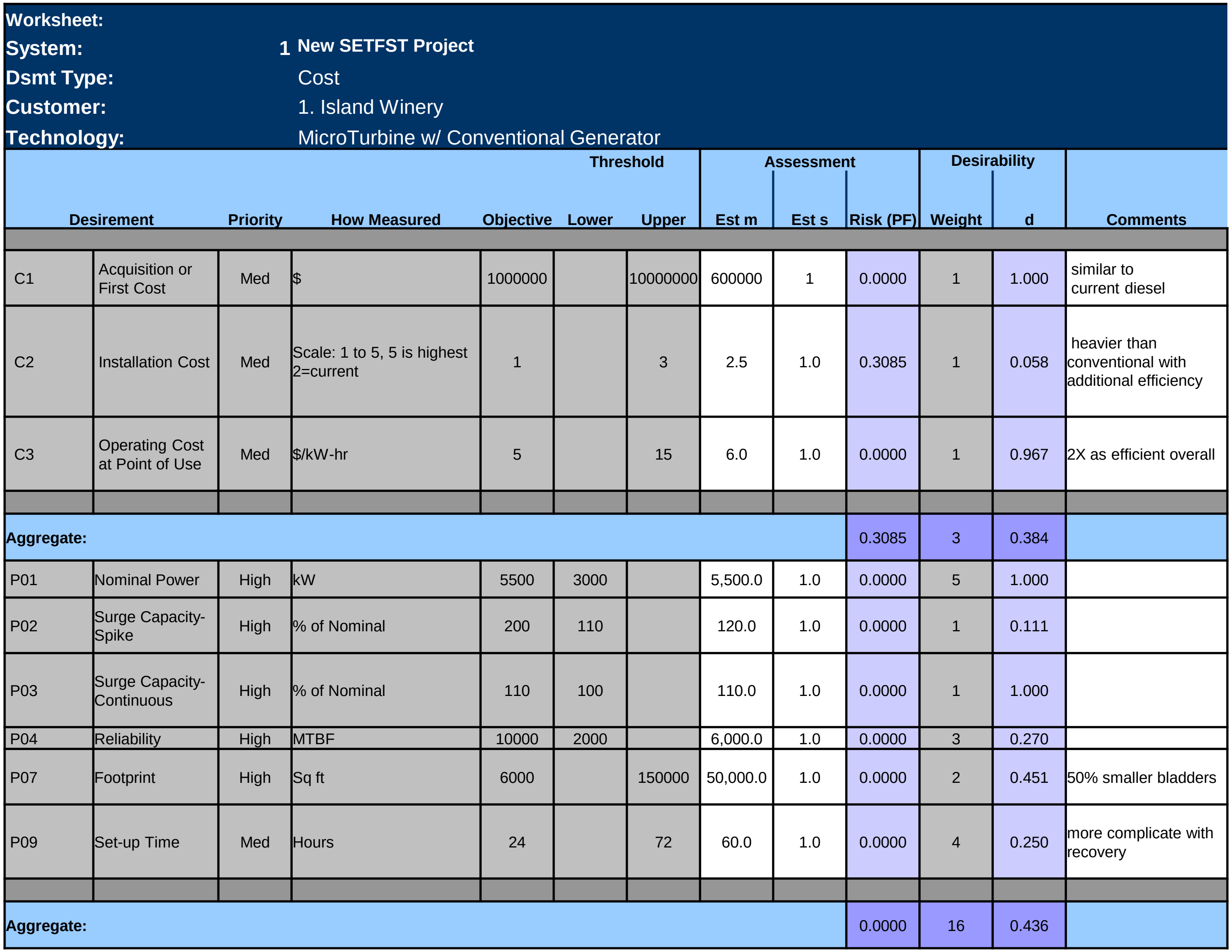
Desirement - Example



Desirement: Nominal Power [[kW]]

Customer	1. Island Winery
Desirement Number	P01
Priority	High
Desirement Type	Perf
How Measured	kW
Objective	5500
Lower d-Limit	3000
Upper d-Limit	
Objective Type:	More
Curve Style:	S-type Curvilinea
Dsmt Value where d=0	3000
Dsmt Value where d=1	5500
Set Point (Rqmt Value)	4400
Set Point (desirability value)	0.8
Desirability Test Point	4250
Desirability	0.6705
Desirement Description	Continuous power which the system is capable of providing in KW.
Objective Rationale	
Rationale for d-Limit	
Assumption, How Tested or Other Clarification	
Comments	

Worksheet - Example



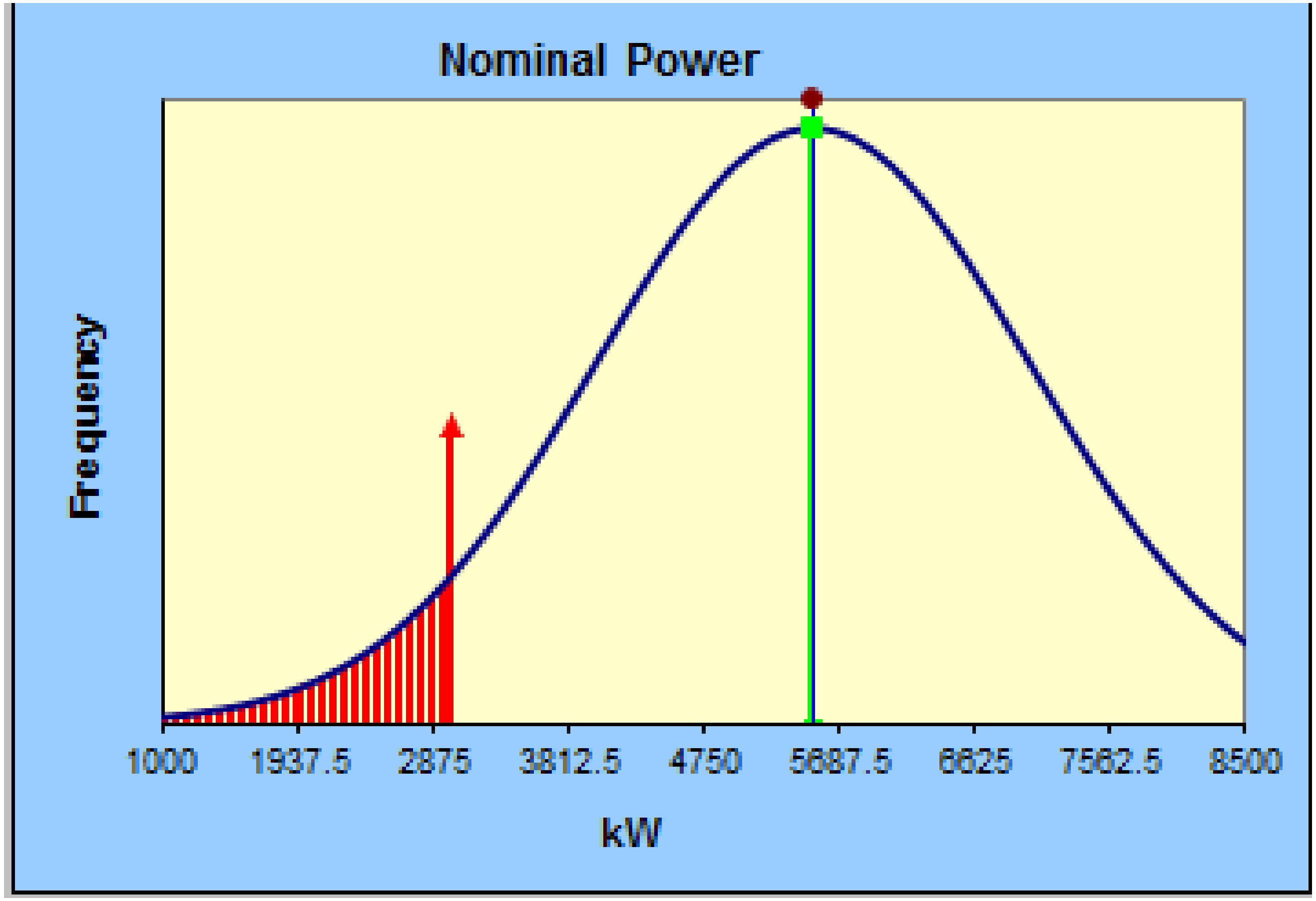
Worksheet:	
System:	1 **New SETFST Project**
Dsmt Type:	Cost
Customer:	1. Island Winery
Technology:	MicroTurbine w/ Conventional Generator

					Threshold		Assessment			Desirability		
Desirement		**Priority**	**How Measured**	**Objective**	**Lower**	**Upper**	**Est m**	**Est s**	**Risk (PF)**	**Weight**	**d**	**Comments**
C1	Acquisition or First Cost	Med	$	1000000		10000000	600000	1	0.0000	1	1.000	similar to current diesel
C2	Installation Cost	Med	Scale: 1 to 5, 5 is highest 2=current	1		3	2.5	1.0	0.3085	1	0.058	heavier than conventional with additional efficiency
C3	Operating Cost at Point of Use	Med	$/kW-hr	5		15	6.0	1.0	0.0000	1	0.967	2X as efficient overall
Aggregate:									0.3085	3	0.384	
P01	Nominal Power	High	kW	5500	3000		5,500.0	1.0	0.0000	5	1.000	
P02	Surge Capacity-Spike	High	% of Nominal	200	110		120.0	1.0	0.0000	1	0.111	
P03	Surge Capacity-Continuous	High	% of Nominal	110	100		110.0	1.0	0.0000	1	1.000	
P04	Reliability	High	MTBF	10000	2000		6,000.0	1.0	0.0000	3	0.270	
P07	Footprint	High	Sq ft	6000		150000	50,000.0	1.0	0.0000	2	0.451	50% smaller bladders
P09	Set-up Time	Med	Hours	24		72	60.0	1.0	0.0000	4	0.250	more complicate with recovery
Aggregate:									0.0000	16	0.436	

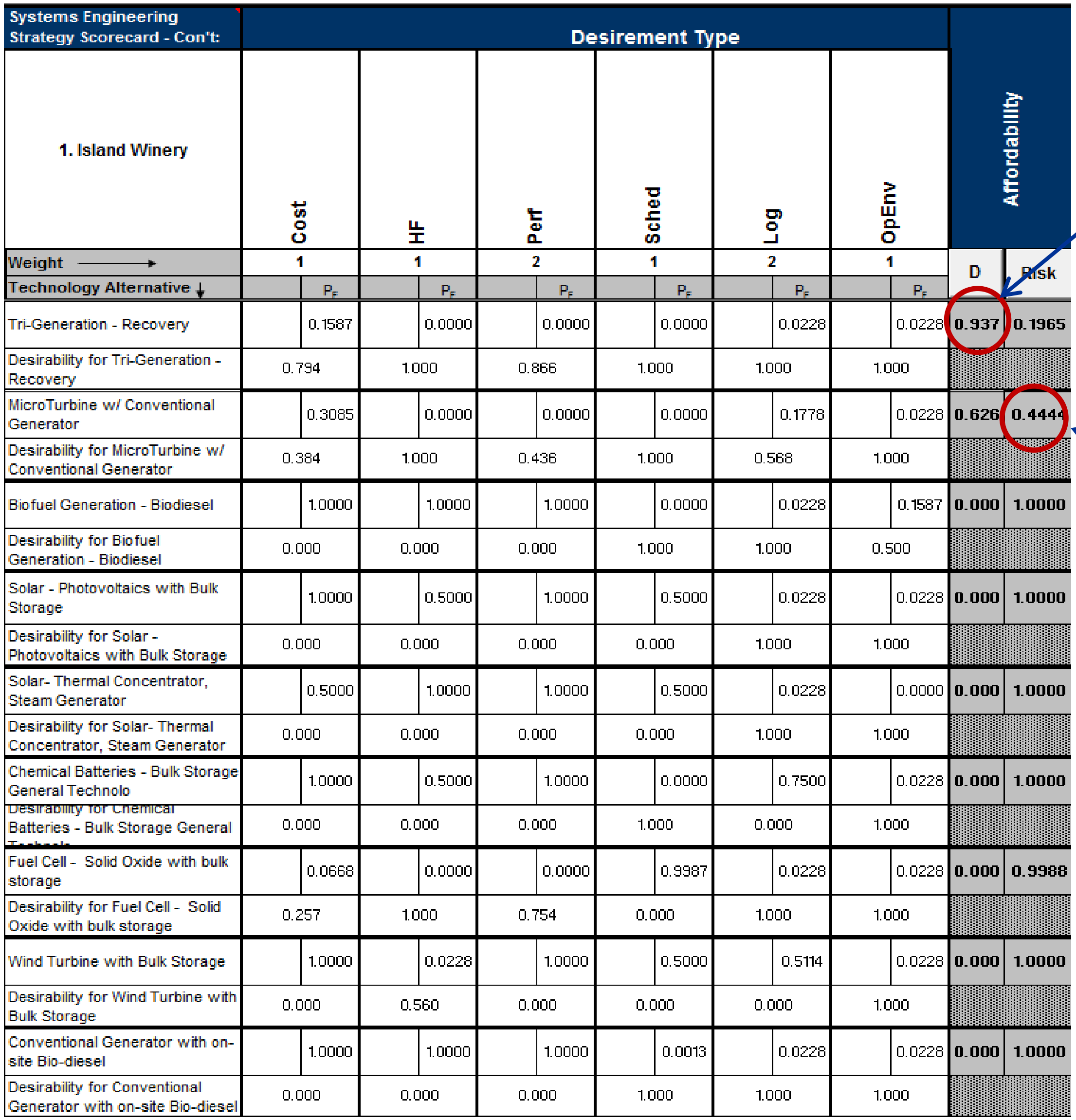
S&T Streamlined Systems Engineering
Risk Identification and Evaluation Techniques

- ***Risk*** identification and evaluation is part of the analysis of alternatives in the S&T Streamlined Systems Engineering approach:
  - Expert judgment from in-house resources
  - Expert judgment from professional risk assessors
  - Simple stratification or ranking
  - Scoring, including weighted scoring; multiple methods
  - Multi-attribute assessments that deal simultaneously with multiple factors
  - Probabilistic modeling and simulation, gaming simulation
    - Modeling and simulation are powerful, but can be expensive; costs are coming down and the environment is more comprehensive
    - Models can be wrong or misunderstood.
    - What happens to one individual or event has a small probability of reflecting the actual highest probability (often the mean) expected outcome and, in fact, no actual "highest probability" event may ever occur.

Risk Chart from SEADS Toolkit



Composite Score Sheet Example

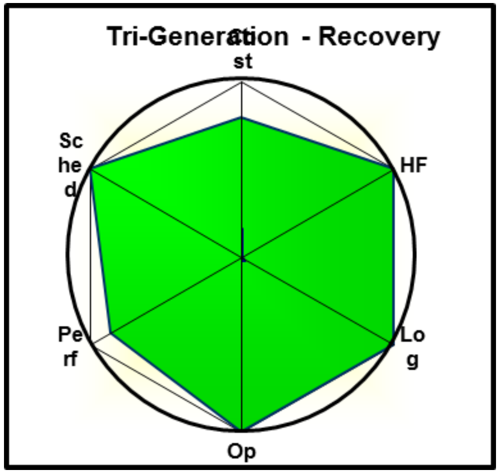


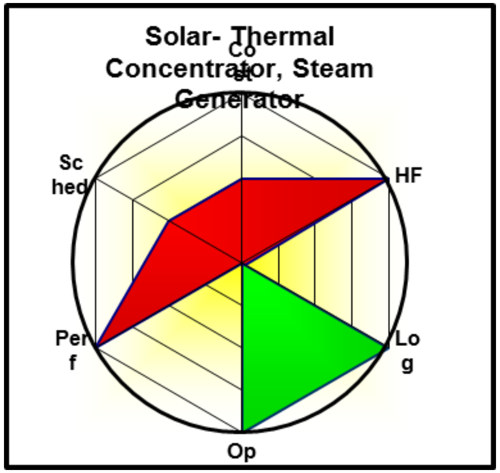
Systems Engineering Strategy Scorecard - Con't:	Desirement Type						Affordability	
1. Island Winery	Cost	HF	Perf	Sched	Log	OpEnv		
Weight →	1	1	2	1	2	1	D	Risk
Technology Alternative ↓	P_F	P_F	P_F	P_F	P_F	P_F		
Tri-Generation - Recovery	0.1587	0.0000	0.0000	0.0000	0.0228	0.0228	0.937	0.1965
Desirability for Tri-Generation - Recovery	0.794	1.000	0.866	1.000	1.000	1.000		
MicroTurbine w/ Conventional Generator	0.3085	0.0000	0.0000	0.0000	0.1778	0.0228	0.626	0.4444
Desirability for MicroTurbine w/ Conventional Generator	0.384	1.000	0.436	1.000	0.568	1.000		
Biofuel Generation - Biodiesel	1.0000	1.0000	1.0000	0.0000	0.0228	0.1587	0.000	1.0000
Desirability for Biofuel Generation - Biodiesel	0.000	0.000	0.000	1.000	1.000	0.500		
Solar - Photovoltaics with Bulk Storage	1.0000	0.5000	1.0000	0.5000	0.0228	0.0228	0.000	1.0000
Desirability for Solar - Photovoltaics with Bulk Storage	0.000	0.000	0.000	0.000	1.000	1.000		
Solar- Thermal Concentrator, Steam Generator	0.5000	1.0000	1.0000	0.5000	0.0228	0.0000	0.000	1.0000
Desirability for Solar- Thermal Concentrator, Steam Generator	0.000	0.000	0.000	0.000	1.000	1.000		
Chemical Batteries - Bulk Storage General Technolo	1.0000	0.5000	1.0000	0.0000	0.7500	0.0228	0.000	1.0000
Desirability for Chemical Batteries - Bulk Storage General Technolo	0.000	0.000	0.000	1.000	0.000	1.000		
Fuel Cell - Solid Oxide with bulk storage	0.0668	0.0000	0.0000	0.9987	0.0228	0.0228	0.000	0.9988
Desirability for Fuel Cell - Solid Oxide with bulk storage	0.257	1.000	0.754	0.000	1.000	1.000		
Wind Turbine with Bulk Storage	1.0000	0.0228	1.0000	0.5000	0.5114	0.0228	0.000	1.0000
Desirability for Wind Turbine with Bulk Storage	0.000	0.560	0.000	0.000	0.000	1.000		
Conventional Generator with on-site Bio-diesel	1.0000	1.0000	1.0000	0.0013	0.0228	0.0228	0.000	1.0000
Desirability for Conventional Generator with on-site Bio-diesel	0.000	0.000	0.000	1.000	1.000	1.000		

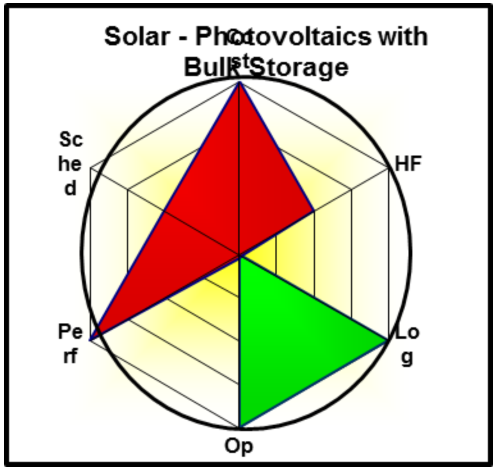
Non-dimensional composite number characterizes the alternative's expectation of meeting all requirements. The higher the better.

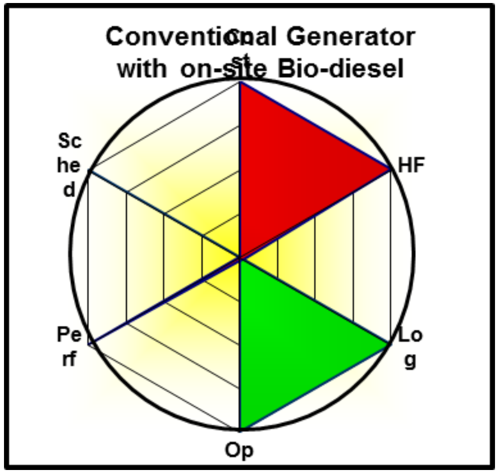
Non-dimensional composite number characterizes the alternative's risk with respect to all alternatives. The lower the better.

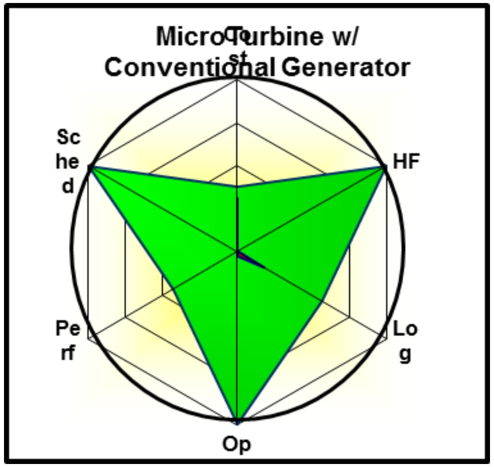
Radar Charts

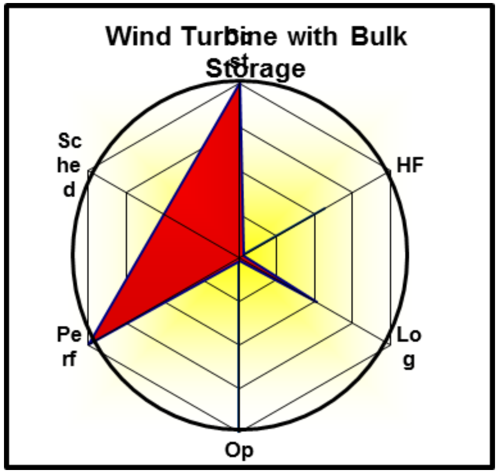

Tri-Generation - Recovery


Solar- Thermal Concentrator, Steam Generator


Solar - Photovoltaics with Bulk Storage


Conventional Generator with on-site Bio-diesel


Micro Turbine w/ Conventional Generator


Wind Turbine with Bulk Storage

Risk Analysis - Executive Level

- ***Desirements*** are strategic; therefore the risks are strategic
- Process is the same in principle, more qualitative in execution
- Evaluation relies heavily on judgment of response to strategic desirements

	Meets one or more strategic objectives	There is a clearly defined, actively engaged customer or sponsor	Customer desirements are explicit and understood	Success is clearly defined, such as an agreed upon ATD and timing	Is a unique AF skill, urgent requirement or AF unique requirement	Represents the best approach among alternatives	Is a critical technology or enabling technology	Composite Score	Composite Risk
WEIGHT	**3**	**3**	**1**	**1**	**2**	**1**	**3**		
PRODUCTS									
S&T Program 1	5	2	5	4	3	2	2	289	0.193
S&T Program 2	3	3	1	1	1	1	1	160	0.244
S&T Program 3	2	1	3	1	3	1	1	147	0.707
…									
S&T Program n									

Risk Issues in S&T
High Risk Is Necessary For High Rewards

- The history of technology is a history of evolution, not revolution
- Evidence is anecdotal: “the plural of anecdote is not data”
- Not accurate in the investment community where the theory originates
- Requires specificity for analysis

Risk Issues in S&T
S&T Is Risk Averse

- Evidence? Is this accurate?
- Risk aversion is a function of risk/value perception
- Risk in S&T is inherently associated with objectives

Risk In S&T — Summary

- Risk in S&T exists at two basic levels: the technical level and the executive (strategic) level.
- Risk is both the probability that something bad will occur and that if it does, it will have significant consequences outside the organization.
- In S&T the probabilities are rarely known and the consequences of an undesirable event may be insignificant or difficult to recognize.
- Risk should be embraced in S&T by striving for significance to the outside.
- Successfully dealing with risk in S&T requires constant monitoring and a responsive approach using a structured process with evolving tools.
- The more significance, the more risk inherent in an S&T project, the more likely it will be managed successfully.

Contact Information

Thomas Archer
SynGenics Corporation
5190 Olentangy River Road
Delaware OH 43015
Email: archer@syngenics.com
Direct phone: 614-442-7858