National Aeronautics and Space Administration

PRE-QUANTITATIVE RISK:
THE SOCIAL CONSTRUCTION OF RISK IN PROJECT TEAMS

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FORUM ON SYNTHETIC BIOLOGY,
SECOND MEETING
PALO ALTO, CA

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AGENDA

Setting the stage

- How this work fits in with what you already know about risk

Risk from a Different perspective

- “Pre-Quantitative” Risk

Stakeholder perceptions of risk relative to success/failure

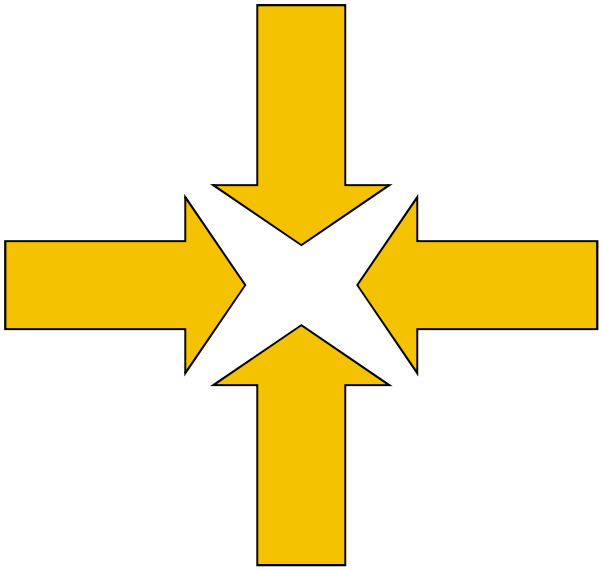
Summary

RESEARCH AT INTERSECTION OF FOUR LITERATURES

Risk

(probability x consequence)

Projects



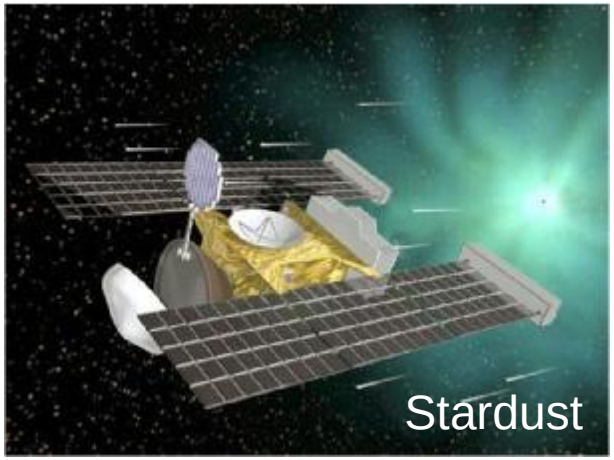
Decision Making

Teams

DOMAIN OF INTEREST

Multi-functional teams working on projects with high technical risk: Deep Space exploration

DSN 70 m Antenna



Pathfinder

DECISION MAKING

Under…	Outcomes	Probabilities	
Certainty[1]	Known	p = 1.0	Preferences
Risk[1]	All Known	All Known	Expected Utility
Uncertainty[1]	All Known	Unknown	Stochastic Processes Monte Carlo
Ignorance[2]	Unknown	Unknowable	Judgment

Fear of "Unknown Unknowns"

[1] Connolly, Arkes, Hammond (1999) *Judgment & Decision Making: An Interdisciplinary Reader*
[2] Zeckhauser & Viscusi (1990), Risk within reason. *Science,* pp559-564.

ASSESSING PROJECT RISK

Mars Helicopter Scout Concept

Experts

x_1
x_2
x_3
x_4
x_n

Inputs Model Output

$\overline{R}_{ex}$

Team

That doesn't make sense

$\overline{R}_{team}$

This is too Risky!

Team

What are these judgments based on?

CHALLENGE …

Understanding *judgments* about risk

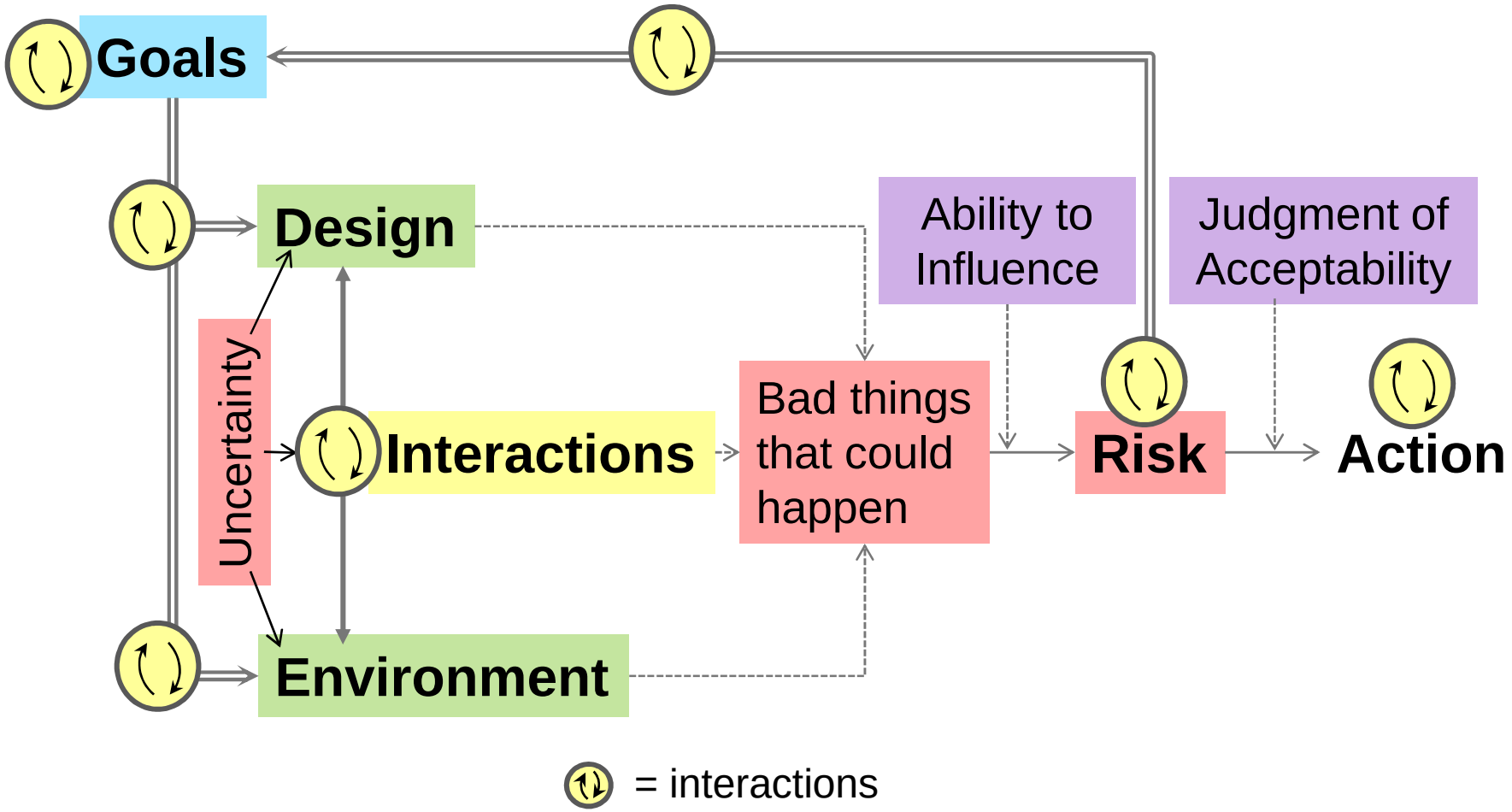
- Ø To support decision making under conditions of "ignorance"
  - Ø On complex, high-cost projects
    - Ø Operating in hostile environments
      - Ø Using cutting edge technology
        - Ø With significant public visibility for failures
          - Ø And amazing opportunities for ground-breaking discoveries

Clues to understanding how teams think about risk can be discerned from how they talk about it

COMPONENTS OF PRE-QUANTITATIVE RISK

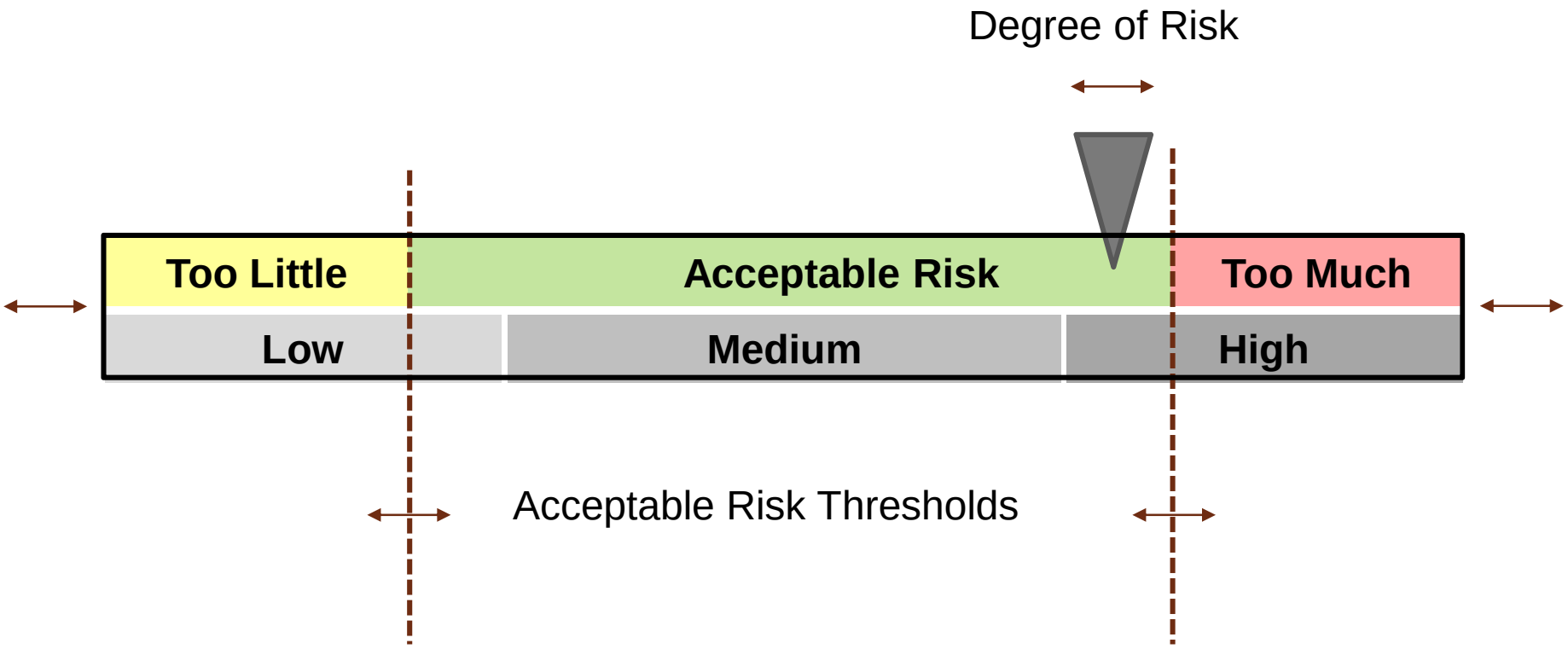
- Goals
- Design
- Environment
- How things interact
- Bad things that could happen
- What they don't know
- What they could influence/control
- Acceptable levels of risk

RELATIONSHIPS OF COMPONENTS



VISUALIZING RISK: SLIDERS

perceptions of



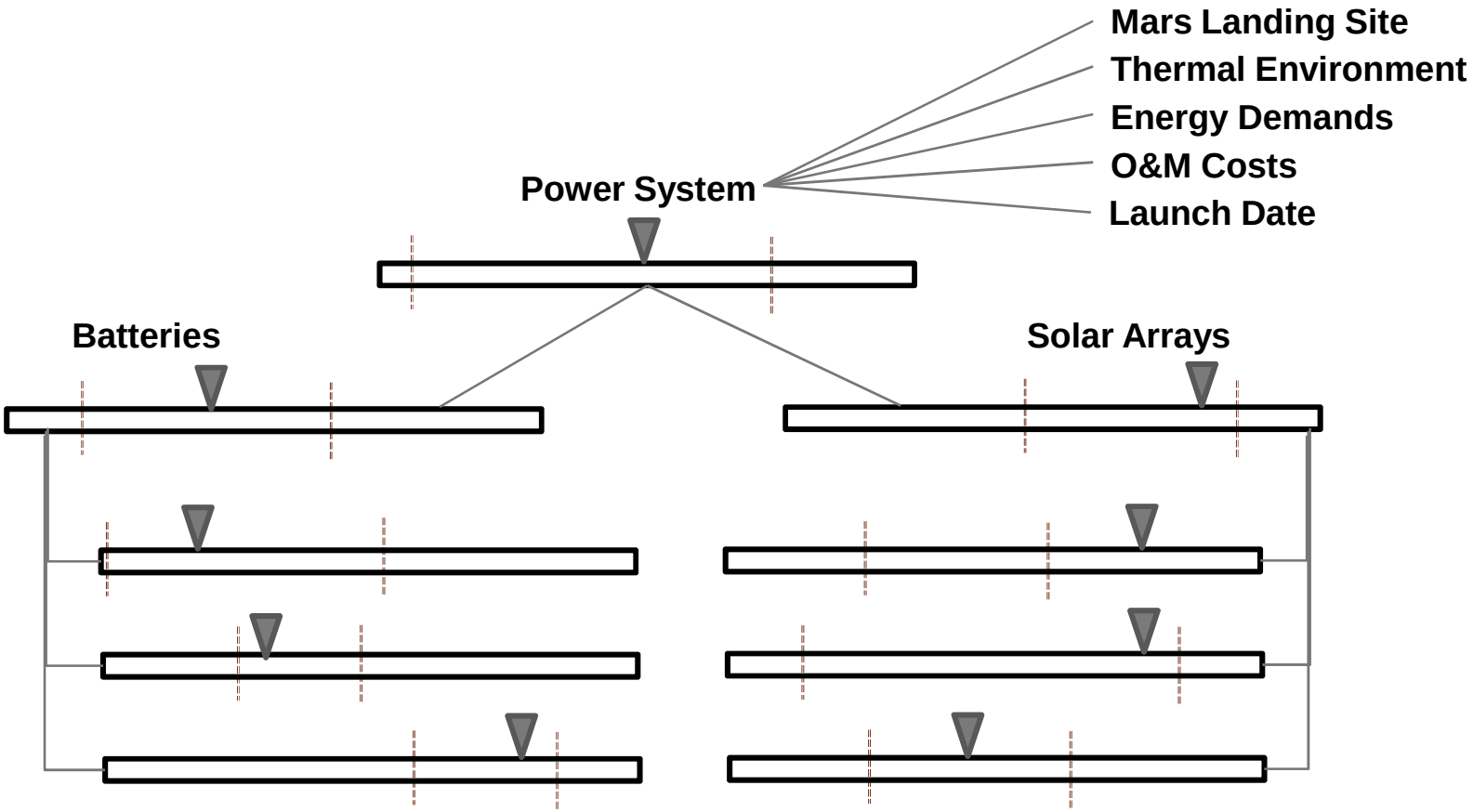
Note: descriptive, not prescriptive

AGGREGATING RISK

perceptions of

- **Contributors to risk “stack up” or “pile up”**
- **Not strictly additive, but in general, the more things on the stack – the higher the perception of risk**
- **Not linear**
- **Not quantitative**
- **“Acceptable Risk” for any subsystem influenced by level of total system risk**
- **Highly dynamic**
- **Strange couplings**

AGGREGATING RISK



WHAT INCREASES RISK?

^ *perceptions of*

Inability to predict behavior

- Cause & effect
- Interactions (complexity)
- Lack of intuition about interactions

Competing/Multiple goals (scope)

- Interactions (complexity)

Uncertainty

- Changes in the environment
- Harshness of the environment

Constrained resources

- Lack of flexibility

Past experience with specific negative outcomes

WHAT DECREASES RISK?

^ *perceptions of*

Many potential solutions to problems

- Previous success

Decoupling

- Break interactions

Predictability

- Ability to model performance and behavior
- Increasing intuition (e.g., by testing, simulation)
- Well characterized, stable environment

Familiarity

Access to resources

"Acceptable" risk:

- Target level of risk

BALANCING RISKS

All areas of the project were not equally risky

Risk assessed at the overall project level

- Decisions about individual areas made to address global vs. localized risk

Team appeared to treat risk as a budget

- Team compensated for areas of higher risk by having lower risk in other areas
- Acted as if there were a not-to-exceed risk threshold

Opportunities addressed based on coincident risks

- An opportunity relative to one goal usually resulted in risk relative to a different goal

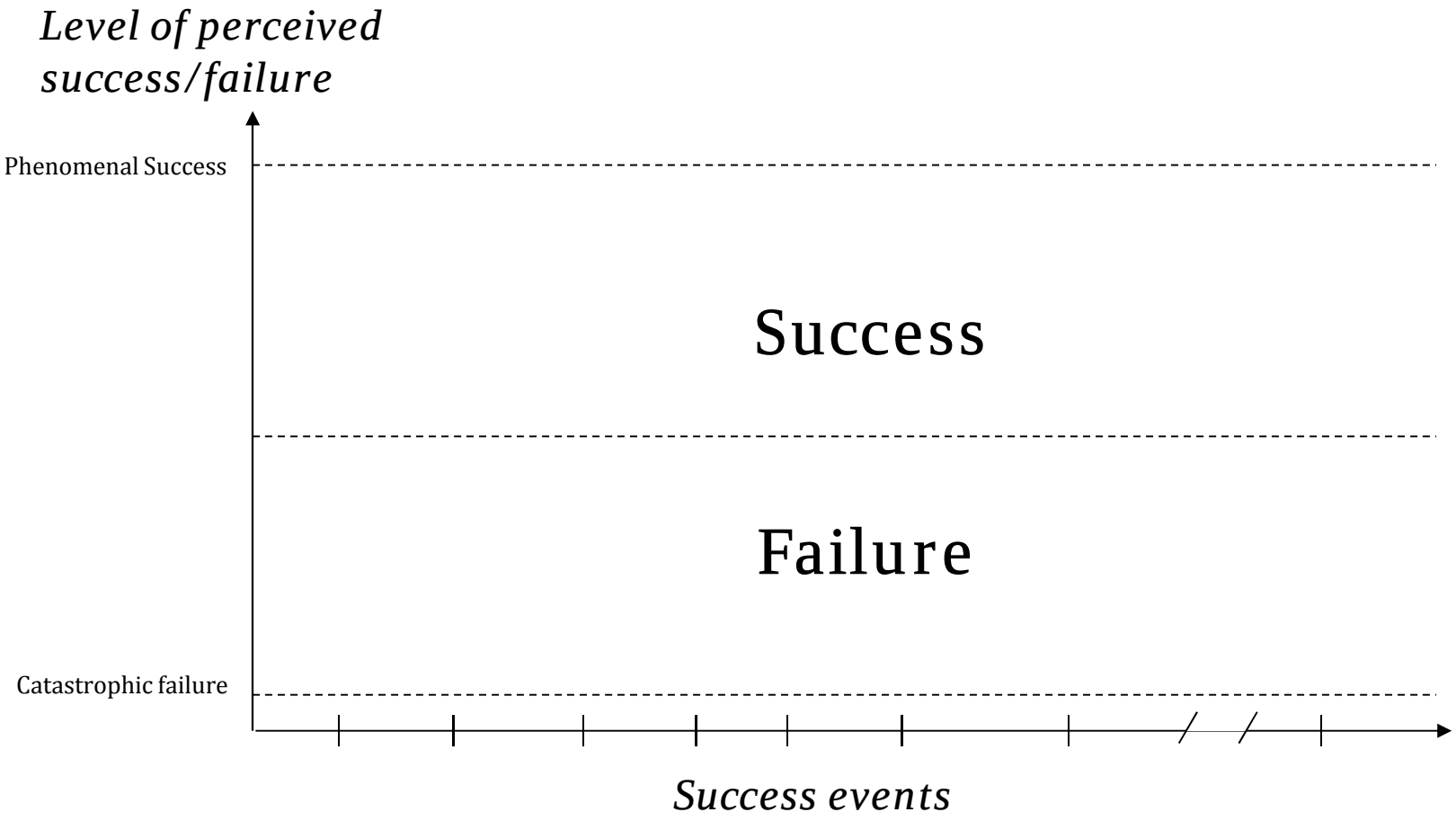
RISK = FAILURE TO MEET GOAL(S)

Without goals, risk doesn't exist

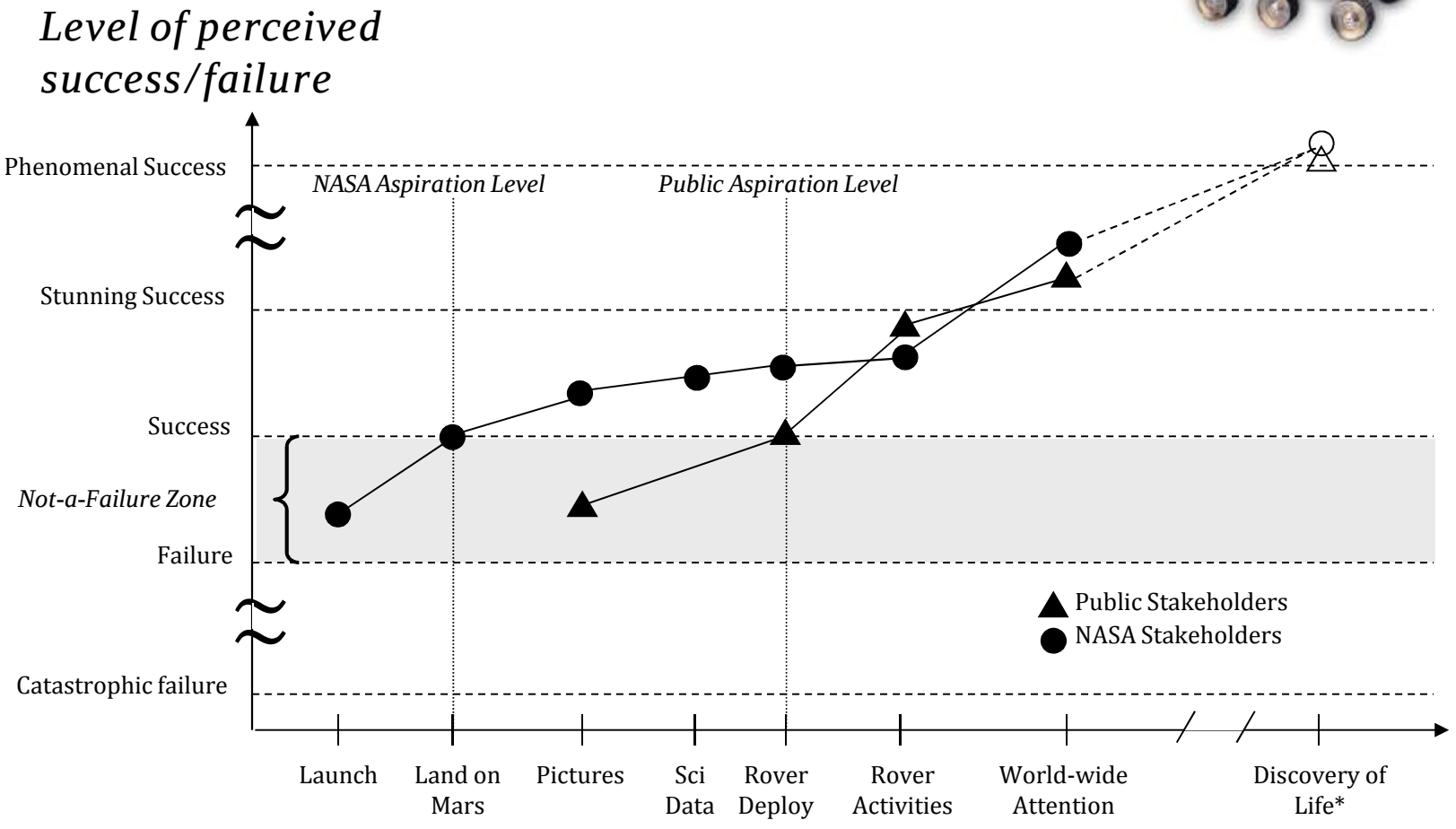
Goals:

- Not always explicit
- Can interact/conflict with one another
- Can often be modified
- Measure success against goals
- Carry different values for different stakeholders
- Setting & managing stakeholder expectations is part of managing risk

DEFINING SUCCESS & FAILURE



DEFINING SUCCESS & FAILURE



* *Please note that this did* not *occur*

IN SUMMARY

Engineers base critical decisions on pre-quantitative conceptions of risk

- "Risk" = Unknown-unknowns

Pre-Quantitative Risk includes

- Interactions among goals, design elements, environments, risks, assessments of riskiness
- Broad view of uncertainty
- Ability to influence, accessibility of solutions impact judgments about the amount of risk
- Judgments on acceptability of risk are made qualitatively

Managing risk – to reduce total amount of risk

Balancing risk – to ensure total amount is acceptable

Stakeholder perceptions of risk (and success or failure) vary based on aspiration levels

" The revolutionary idea that defines the boundary between modern times and the past is the mastery of risk: the notion that the future is more than a whim of the gods and that men and women are not passive before nature "

Peter L. Bernstein, 1996, p.1

THANK YOU

SOURCES

Content pulled from multiple papers

- *How Project Teams Conceive of and Manage Pre-Quantitative Risk.* Dissertation. (2008)
- A Team Mental Model Perspective of Pre-Quantitative Risk. *Proceedings of the 44th Hawaii International Conference on System Sciences*, Kauai, Hawaii, January 4-7, 2011.
- Assessing Risk from a Stakeholder Perspective*. Proceedings of the IEEE Aerospace Conference*, Big Sky MT, March 2003.
- The Influence of Risk Perspectives on Project Teams. *INFORMS 2003,* Technology Management Track.
- Understanding Pre-Quantitative Risk in Projects. *Proceedings of the Ninth Annual Conference on Systems Engineering Research*, Redondo Beach, CA, April 15-16, 2011.
- A Research Agenda to Reduce Risk in New Product Development through Knowledge Management: A Practitioner Perspective*. Journal of Engineering and Technology Management,* 20, 117-140. (2003)

Images: JPL & NASA Websites

Recommended Reading:

- *The Power of Intuition*, G. Klein
- *Against the Gods: The Remarkable Story of Risk*, Peter Bernstein
- *Target Risk 2: A New Psychology of Safety and Health*, G. J.S. Wilde
- *Blah Blah Blah: What to Do When Words Don't Work*, Dan Roam