AMERICAN SOCIETY OF
SAFETY PROFESSIONALS

Central Valley Chapter

Lessons in Human Factors from the Space Shuttle Challenger Disaster

28 April 2021

David Hazell

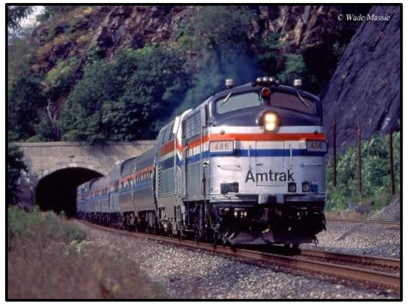
Objectives

1. Define a High Reliability Organization
2. Define “Drift”
3. Explore a case study from NASA
   - Discuss factors that led to Space Shuttle Challenger disaster
   - Identify lessons
4. Evaluate how case study concepts and lessons apply to your organization and culture

High-Reliability Organization Definition

- **High-Reliability**
  - Repeatedly delivers successful, predictable results in a dynamic, technologically complex, time-constrained, and high-hazard environment ...
  - **Must "get it right" the first time...every time**

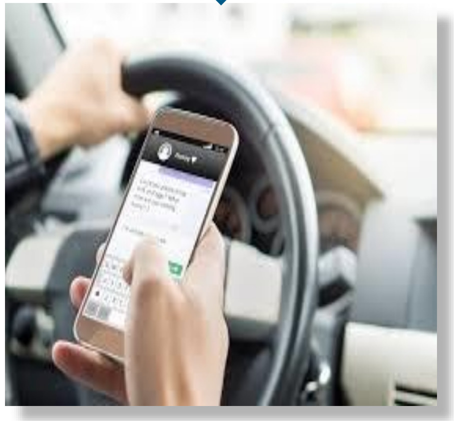
High-Reliability Organizations



Normal Drift is the movement away from the desired standard

SPEED
LIMIT
40

Decisions and behaviors repeated without catastrophic results



Space Shuttle Challenger

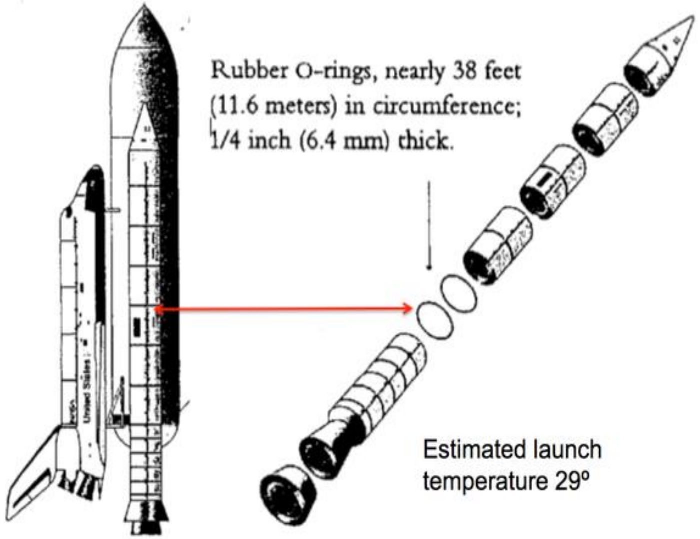
Case Study

Space Shuttle Challenger

28 January 1986

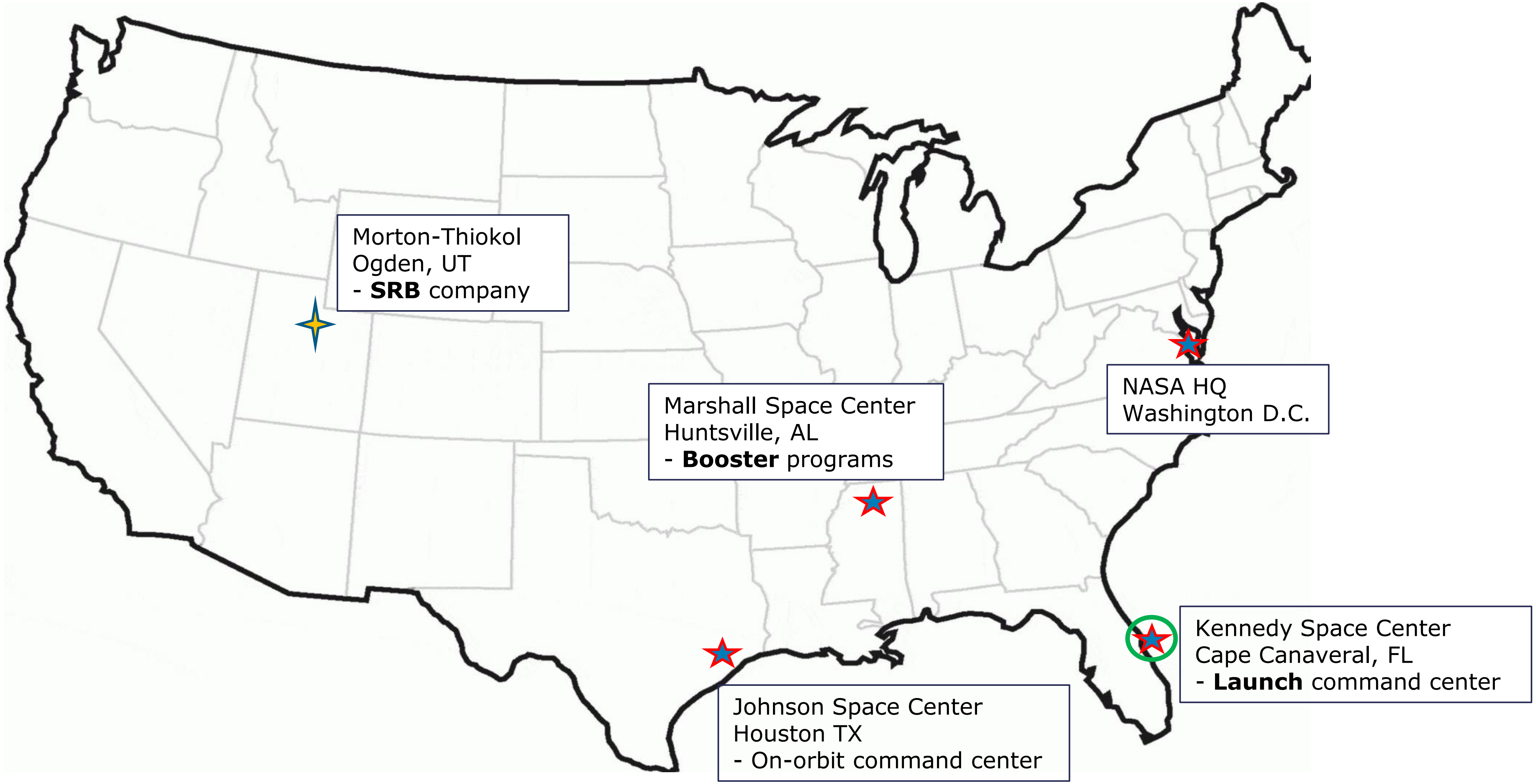
- NASA's last fatality was 19 years earlier
  - Only 1 fatal disaster in 25 years and 55 missions
- Perfect Space Shuttle Safety Record
  - Over 9,000 mishap-free hours in orbit
- Space Shuttle program was the centerpiece of NASA operations…
  - International symbol of success

Cause was a failure of both primary and backup O-rings


Rubber O-rings, nearly 38 feet
(11.6 meters) in circumference;
1/4 inch (6.4 mm) thick.
Estimated launch
temperature 29º

There was a considerable human element to this disaster….

Key Decision-Makers



Morton-Thiokol
Ogden, UT
- **SRB** company

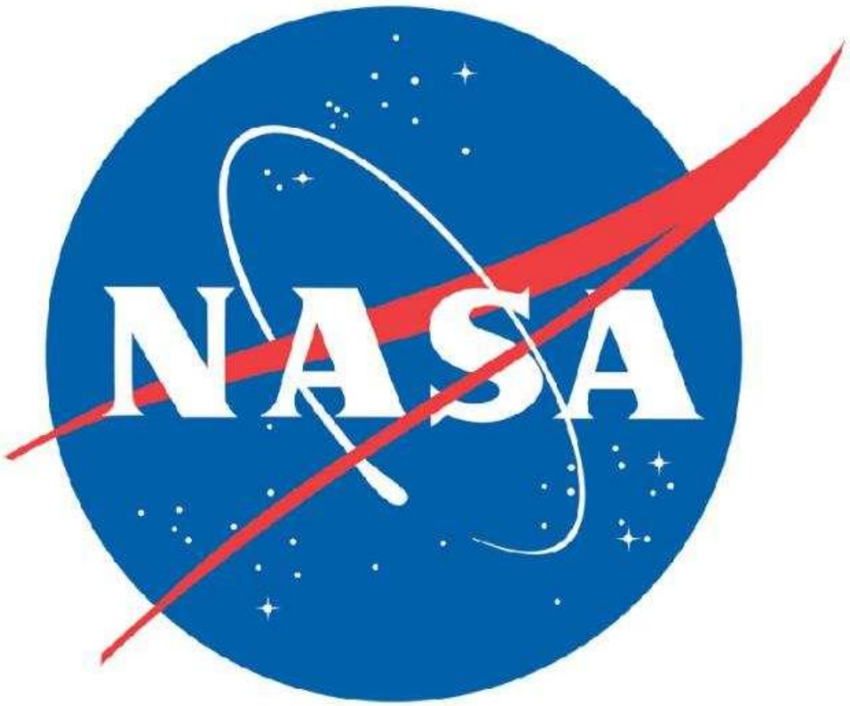
Marshall Space Center
Huntsville, AL
- **Booster** programs

NASA HQ
Washington D.C.

Kennedy Space Center
Cape Canaveral, FL
- **Launch** command center

Johnson Space Center
Houston TX
- On-orbit command center

A History of Insidious Compromise



Failure is **not** an option

How Deviations Became Normal Practice

- Engineers observed defects to rocket booster O-Rings
- Manager aware but did not forward memos
- 14 of 24 launches showed damage to O-rings
- Designated Critical 1 component
- 7 out of 9 launches in 1985 showed erosion
- Erosion treated as an “acceptable risk”
- Waivers issued
- Redesign began
- Failure to listen to experts
- Repeated successful launches?

Fatal Decisions

- Decision to continue using a ***known*** faulty design over several missions despite growing and overwhelming data
  - Leadership allowed the “drift” to happen
- SRB contractor managers’ dismissal of the group of Engineers who issued an unprecedented “no-launch” recommendation
- NASA did not follow own safety rules regarding “Critical 1” components
- Yielding to schedule pressure…
  - 4 previous launch postponements, including launch scrub the previous day
  - High-profile crew and publicity

A Constantly Shifting Definition of Acceptable Risk

- Over time, unexpected events become expected and "normal"…
- Now acceptable on day of disaster[1]:
  - **Joint expansion** vice contraction
  - Normal to have heat on primary O-ring →

    Normal to have erosion of primary O-ring →

    Normal to have hot gases leaking past primary O-ring →

    Normal to have erosion of secondary O-ring
  - **Routine waiver of "Critical 1" issues**

[1] – Vaughan, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*

A Constantly Shifting Definition of Acceptable Risk

> *Once you've accepted an anomaly or something less than perfect, …you've given up your virginity. You can't go back. You're at the point that it's very hard to draw the line. …next time they say it's the same problem, it's just 5 mils more.*
>
> - Larry Wear, Solid Rocket Booster Program Manager

[1] – Vaughan, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*

Why Do Organizations "Drift" Away From High Reliability?

- Pressure to perform, meet goals, save time, save money
- Complacency, experience, etc.
  - "Nothing bad has happened in____"
- Imperfect knowledge of standards
- A belief that "Rules are stupid and inefficient" / "It won't happen to me"
- Incorrect incentives (rewards, sanctions, etc.)
- Leaders fail to empower team members to enforce standards
- High performance ***culture*** is missing

Normal Drift vs. Normalized Deviation

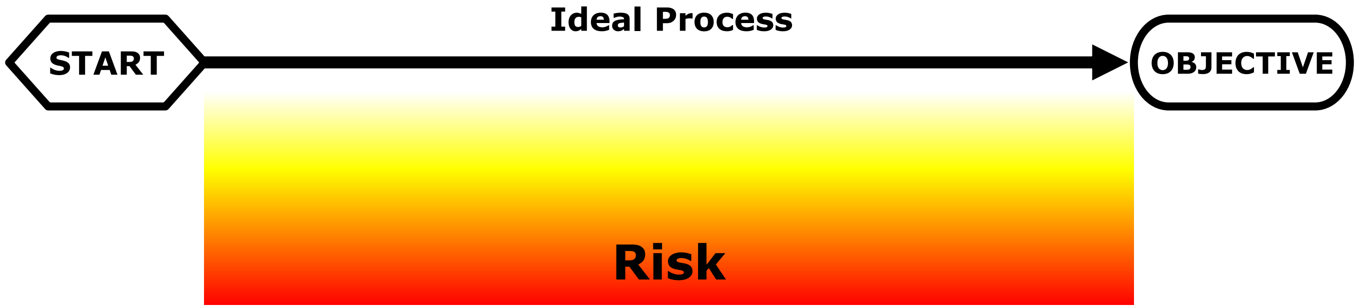
Design

(Equipment, Environment, Planned Use, etc.)

Planned Execution

(SOP’s, Procedures, Checklists, Process Improvements, etc.)

Work as Intended

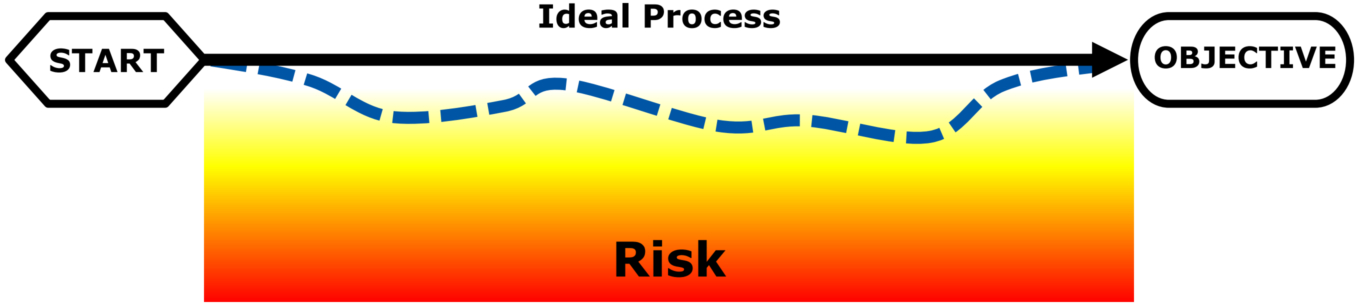


Normal Drift vs. Normalized Deviation

Work as Executed

Actual Execution

(SOP's, Procedures, Checklists, Process Improvements, etc.)



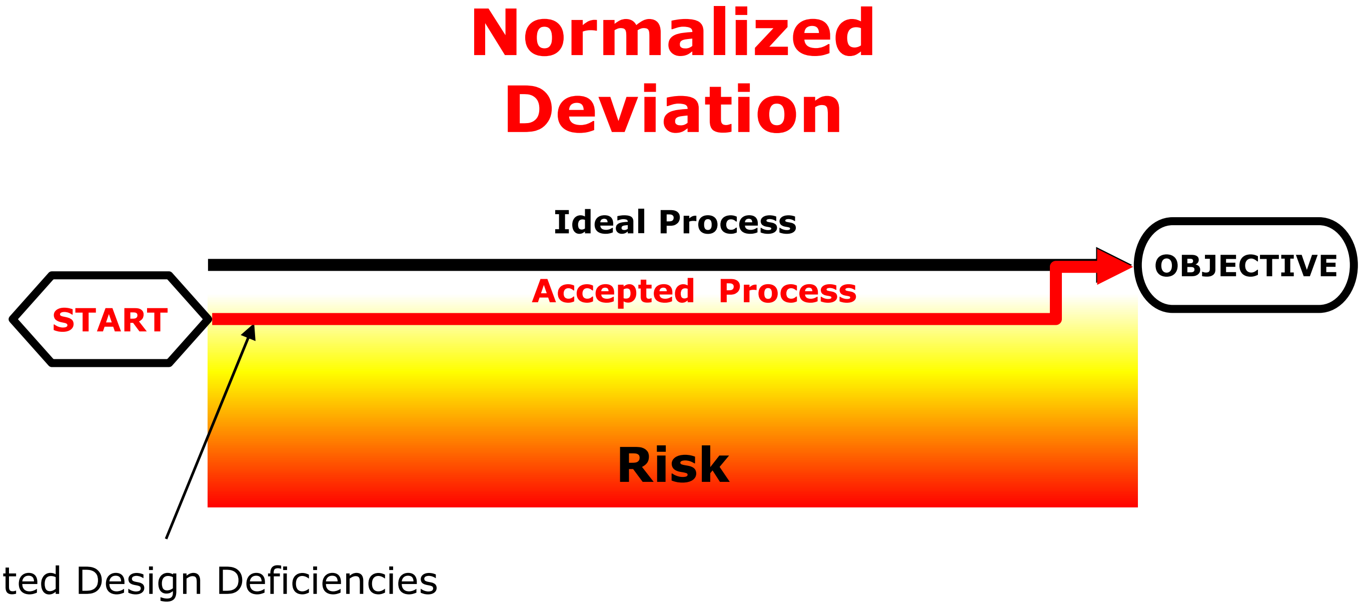
Normal Drift vs. Normalized Deviation

Design

(Equipment, Environment, Planned Use, etc.)

Actual Execution

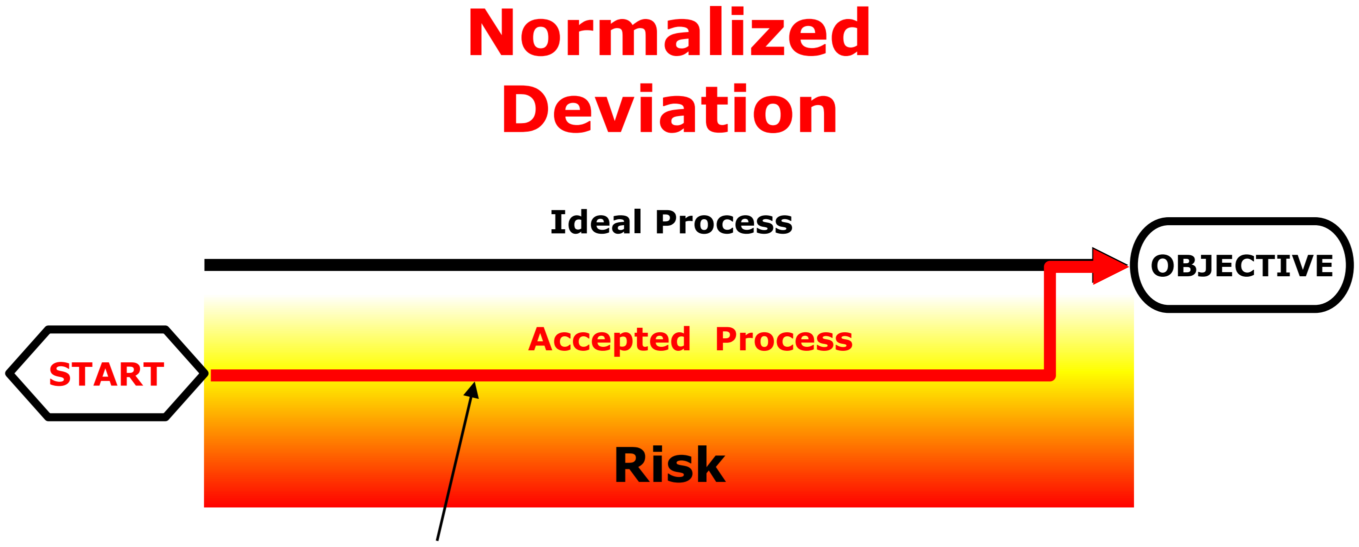
(SOP's, Procedures, Checklists, Process Improvements, etc.)



Normal Drift vs. Normalized Deviation

Design
(Equipment, Environment,
Planned Use, etc.)

Actual Execution
(SOP’s, Procedures, Checklists,
Process Improvements, etc.)



Accepted Design Deficiencies + Failure to Leverage Data

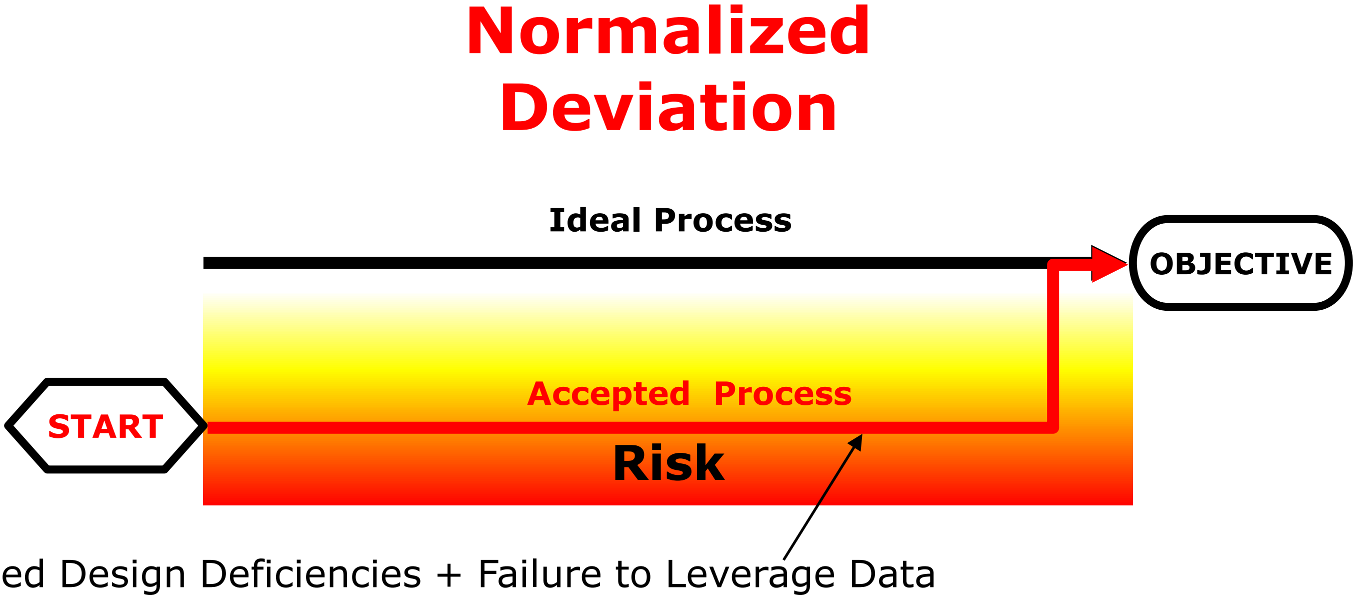
Normal Drift vs. Normalized Deviation

Design

(Equipment, Environment, Planned Use, etc.)

Actual Execution

(SOP’s, Procedures, Checklists, Process Improvements, etc.)



Normal Drift vs. Normalized Deviation

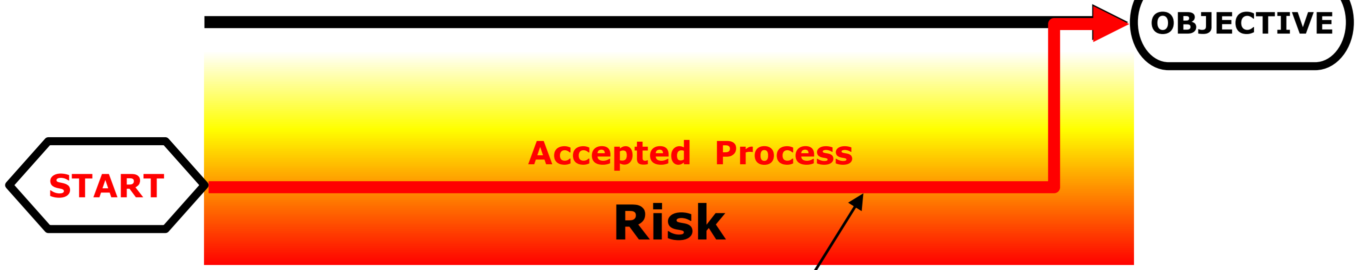
Design

(Equipment, Environment, Planned Use, etc.)

Actual Execution

(SOP’s, Procedures, Checklists, Process Improvements, etc.)

Normalized Deviation



Accepted Design Deficiencies + Failure to Leverage Data

+

Poor Judgement (Routine disregard for Standards)

Normal Drift vs. Normalized Deviation

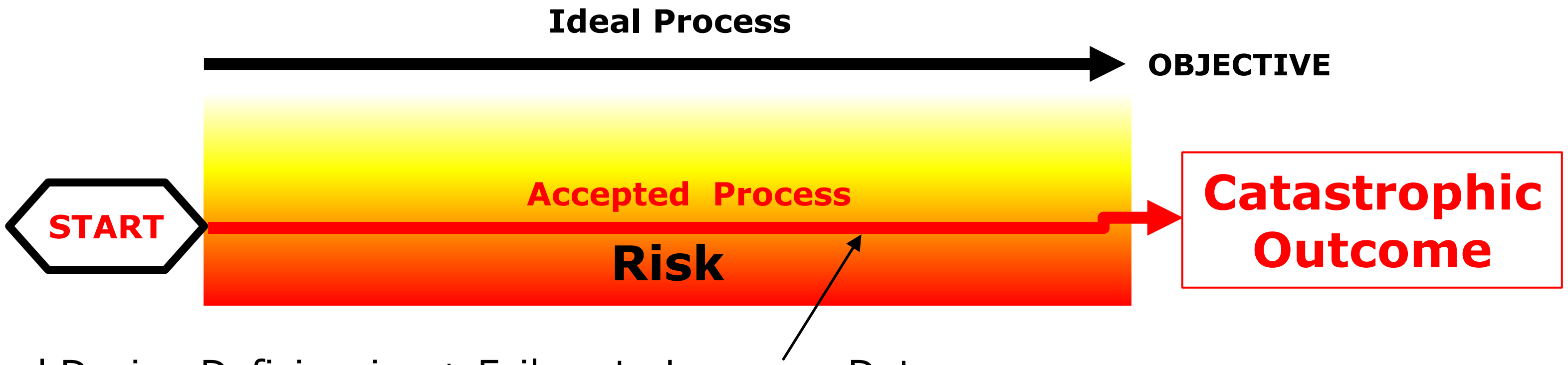
Design

(Equipment, Environment, Planned Use, etc.)

Actual Execution

(SOP's, Procedures, Checklists, Process Improvements, etc.)

Normalized Deviation



Ideal Process

OBJECTIVE

START

Accepted Process

Risk

Catastrophic Outcome

Accepted Design Deficiencies + Failure to Leverage Data

+

Poor Judgement (Routine disregard for Standards)

Realistic Operations – Managing Acceptable Drift

Actual Execution Based on Standards and Teamwork

(Continually improve processes based on data, lessons learned, and empowerment of frontline workers – include contingencies & resilience measures)

Ideal Process

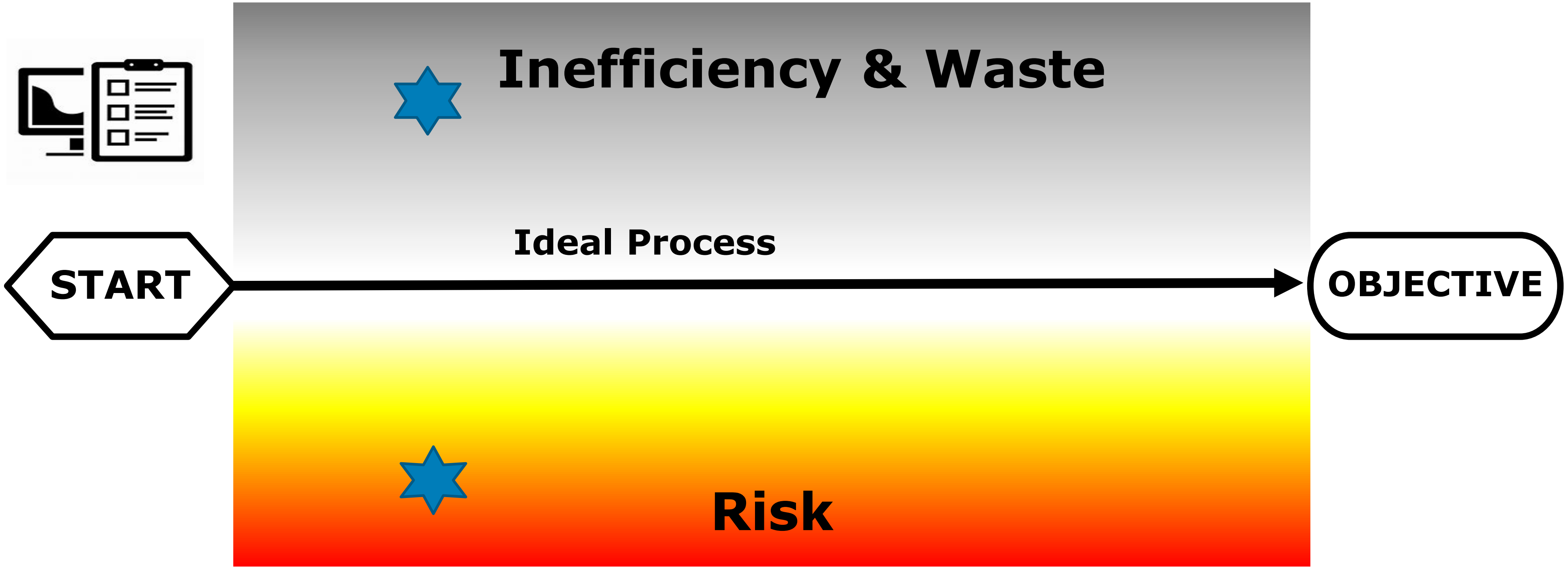
START

OBJECTIVE

Realistic Operations – Managing Acceptable Drift

Actual Execution Based on Standards and Teamwork

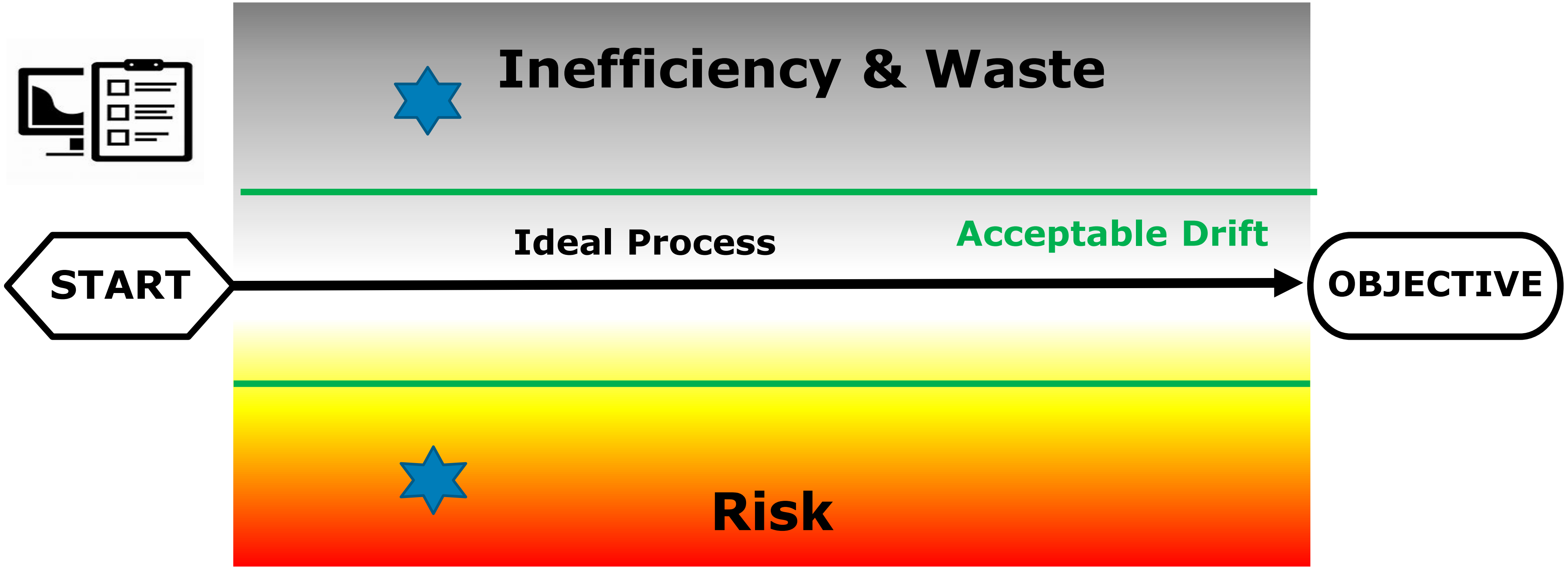
(Acknowledge both safety and operational mission goals – efficiency, quality, profitability, etc.)



Realistic Operations – Managing Acceptable Drift

Actual Execution Based on Standards and Teamwork

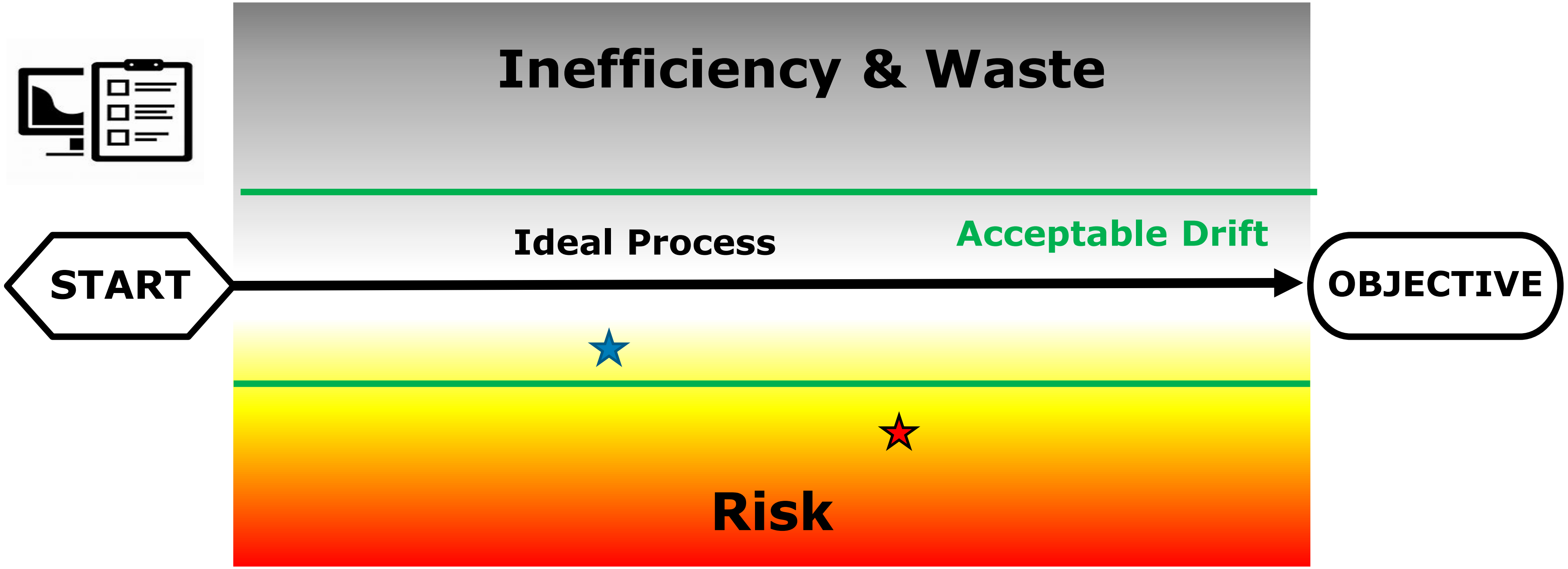
(Clearly define and communicate limits of acceptable drift – accounts for dynamic environment, unexpected events, flexibility, technique, etc.)



Realistic Operations – Managing Acceptable Drift

Actual Execution Based on Standards and Teamwork

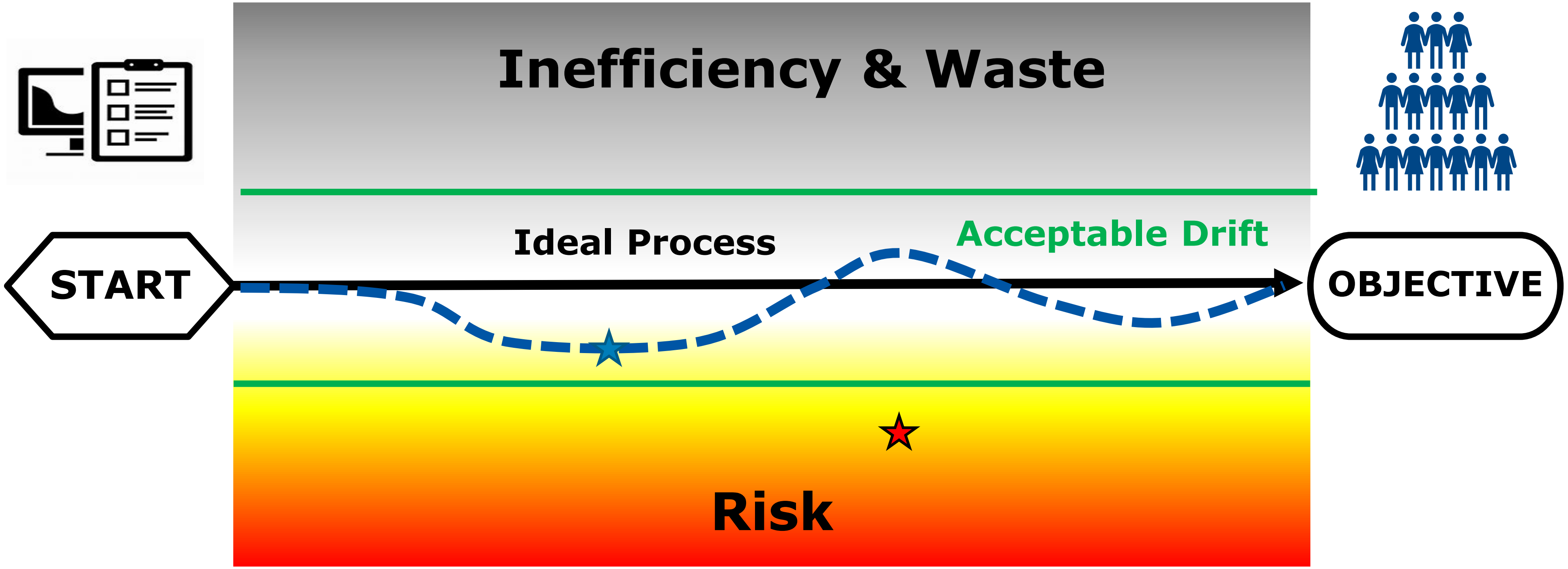
(Clearly define and communicate limits of acceptable drift – accounts for dynamic environment, unexpected events, flexibility, technique, etc.)



Realistic Operations – Managing Acceptable Drift

Actual Execution Based on Standards and Teamwork

(Reference the Standards - SOP’s, Procedures, Checklists, etc.)
(Use **Teamwork** - Crosschecks, Mutual Support, Forceful Team Backup, etc.)



Excessive Drift is Easier to Prevent Than to Correct

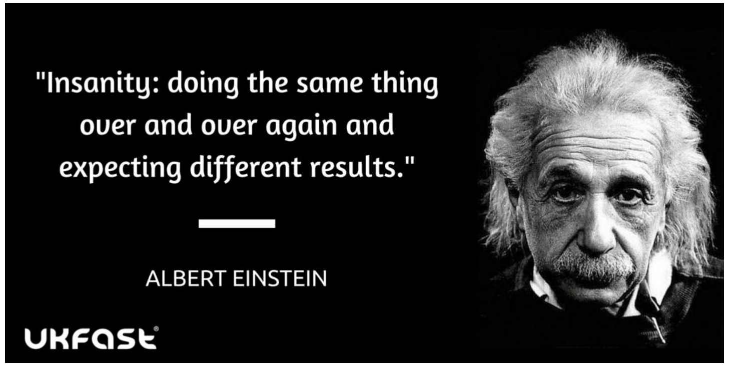
- Leaders Set the Tone
  - Set high standards…strive for perfection!
  - If leaders break rules, others will feel it acceptable to CHOOSE which rules to follow
  - Be clear when communicating standards and consequences of not meeting them
- Empower and reward enforcement of standards
- Recognize your vulnerability…
- Continuously learn & improve from ***both*** success and failure

Self Assessment…

- What waivers do we have in place concerning safety?
- Do we include lessons-learned and best practices in process revision, future plans, and operations?
  - How often do we review lessons-learned, incidents, near misses, etc.?
  - Do we “blame and punish” or “learn and improve”?
- Are we rewarding the behaviors we want repeated?
  - Promotions, rewards, bonuses, incentives, etc.
- Where have we deviated from expected standards?
- Is there a clear and common understanding of acceptable and unacceptable drift?
  - Do all people feel empowered to speak up if drift/deviation is excessive?

Key Takeaways

- Drift is normal
- Drift is easier to prevent than correct
- It starts with the leadership
  - Define Acceptable Drift
  - Communicate it
  - Enforce
- Beware operational pressures
- Regularly review the processes to learn



"Insanity: doing the same thing over and over again and expecting different results."

ALBERT EINSTEIN