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Shortfall Analysis and Creative Approaches to Problem Quantification and Monetization

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Introductions

Introductions

George Bayer

- Senior Director at Cobec Consulting
- Currently leads investment analysis consultant teams developing costs, benefits, and business cases for FAA acquisitions
- B.S. in Business Administration (Finance & English majors) from the University of Florida
- MBA in Corporate Finance from The University of Texas at Austin
- Project Management Institute (PMI) Project Management Professional (PMP)
- Over 20 years of Finance experience in capital investment valuation, forecasting & budgeting, cost estimation, benefits quantification, and business case development
- Developed discounted cash flow models in Investment Appraisal for major Power Generation capital investments at ConocoPhillips
- Evaluated major capital investments/acquisitions in the Business Case Group of Investment Planning & Analysis at the FAA

Introductions

Brian Carroll

- Associate Consultant at Cobec Consulting
- B.A. in Mathematics at Kean University
- 3 years of Value Stream Mapping and Benefits and Shortfall Analysis

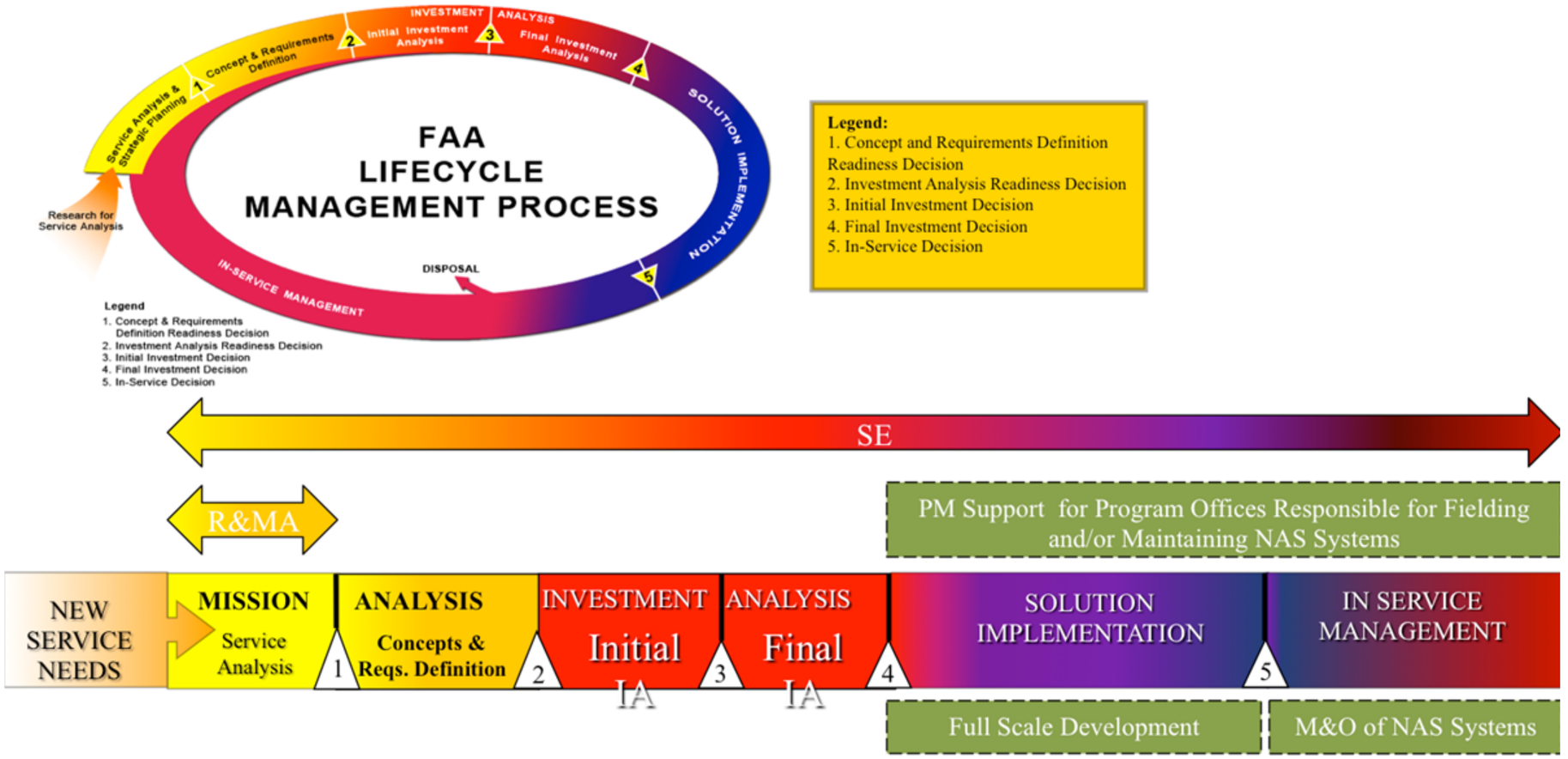
Government Capital Investments

Gov't Acq. for Civil Agencies

- **Government Capital Investments**
  - Each year, government civil agencies allocate billions of dollars to capital investments and Facilities & Equipment (F&E) spending to:
    1. Retain and restore government infrastructure and services
    2. Add new services or capabilities for agencies and stakeholders
       - For the FAA, this includes the flying public, airlines, airports, and transportation infrastructure
    3. Improve agency efficiencies for the delivery of services or capabilities
  - Government agencies develop business cases to measure the value for major capital investments and acquisitions.
  - Civil agency capital investments require **business case justification** for investment approval.
    - Estimate (1) Cost, (2) Benefits, (3) Shortfalls
    - Limited capital budgets, cannot approve all investments
    - Choose highest value investments where benefits > costs

- **Business Cases Start by Solving a Problem or Shortfall**
  - Business cases start with a purpose.
  - Purpose is to solve existing shortfall or problem.
  - Identifying and measuring that problem that the government is trying to solve is critical for investment analysis and is an **artform.**

Investment Lifecycle



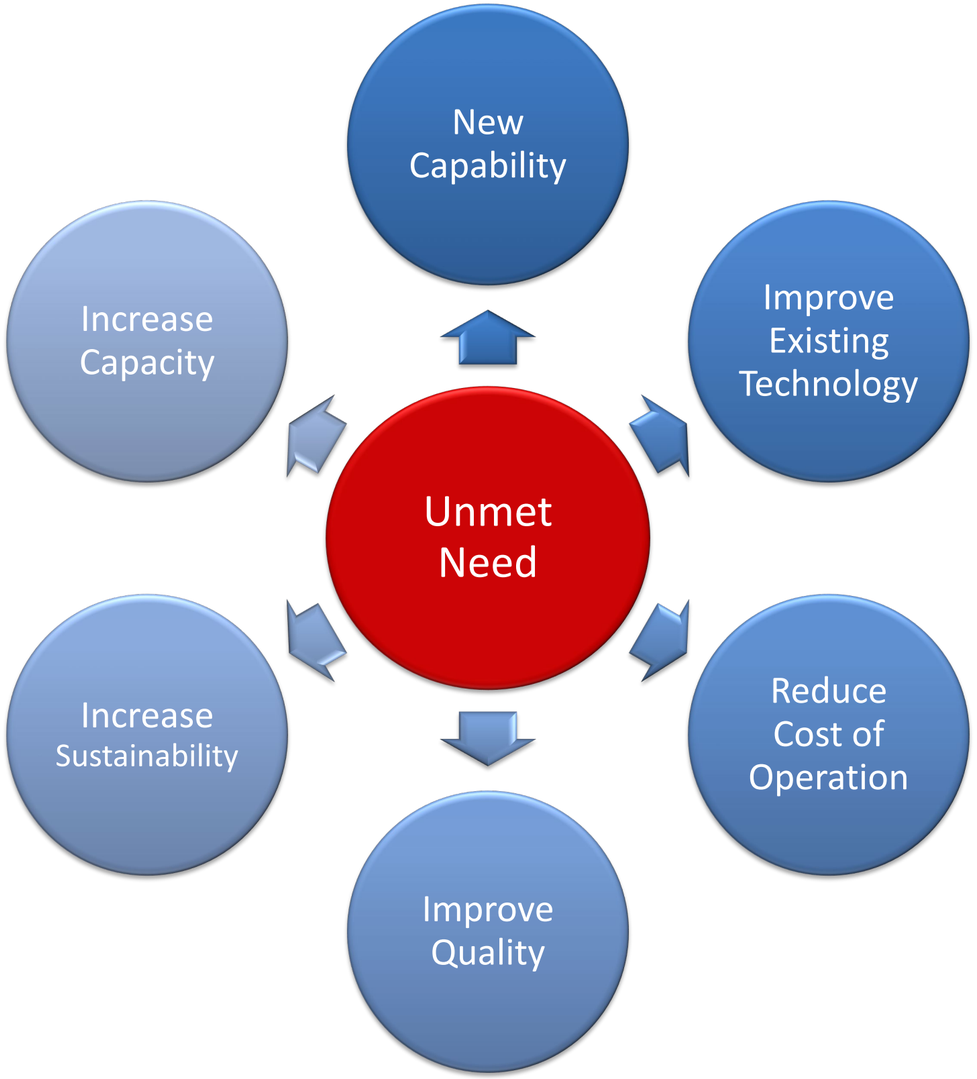
- FAA has its own investment management guidelines, the **Acquisition Management System (AMS)**
- FAST website - https://fast.faa.gov/

Shortfalls – Identifying and Solving Problems

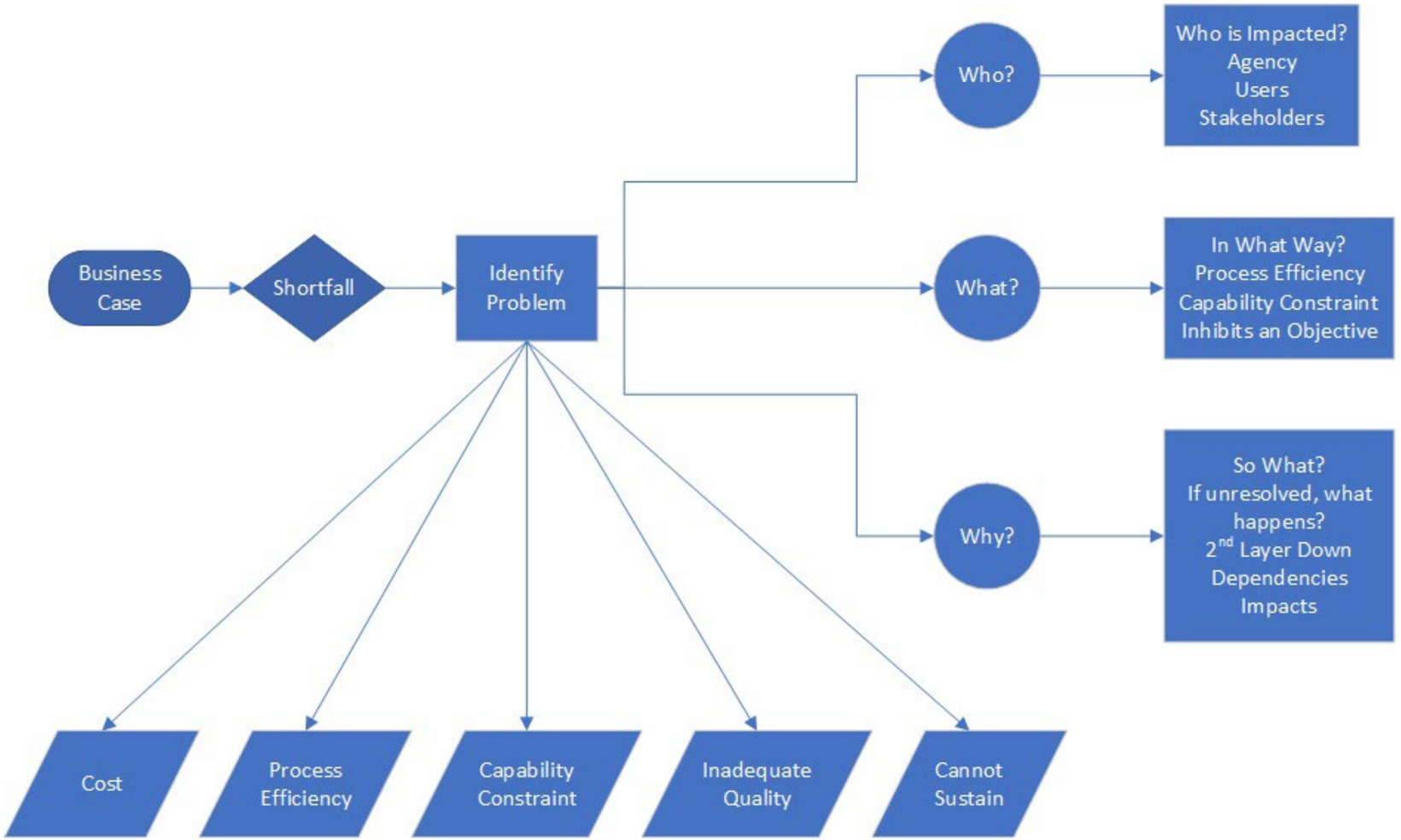
What is Shortfall Analysis?

Shortfall =

- Each major government acquisition or capital investment is initiated to meet an agency or stakeholder need that is not currently being met.



What is Shortfall Analysis?



The **critical questions we ask** when identifying and quantifying a business case shortfall.

- **Who** is being impacted by this shortfall?
- **What** is the constraint or problem they are experiencing?
- **Why** does it matter if this shortfall persists?
- **What is the impact** if we do not resolve this shortfall?
- **How** do these impacts manifest as a problem the agency wants to resolve?

Problem Definition – As-Is vs To-Be

- To understand the problem the agency is trying to solve, analysts need a point of context:
  - Compare Current Legacy System to New Proposed System
  - **"As-Is" versus "To-Be" Analysis**
    1) **Problem Identification** – Understanding the current system state and comparing to intended end-state capability helps identify the problem
    2) **Isolation** – Analyzing the As-Is allows us to isolate the primary problem
    3) **Incremental Quantification** – Identify use cases, compare how users operate in capability deficit in As-Is state to how they would operate with new capability, data, capacity, scale, or efficiency of new system
  - By better understanding what is done now and comparing to the capability that we are solving, we can isolate the problem and the incremental differences between the legacy and the solution.

- **As-Is Capability and Process Analysis Reveals:**
  1) What the agency does now and what process it needs to improve
  2) What capability is missing that it needs to enable
  3) What new service it could provide
  4) What data is missing and if collected could provide better predictive forecasting

Problem Identification – Steps

Steps in Problem Identification – As-Is Versus To-Be Analyses

1. Isolate the Primary Problem
2. Examine the Legacy System Challenge or Obstacle
3. Analyze the Underlying Problems
4. Map out the As-Is State (Process-Oriented)
5. List End-State Goals and Capabilities and Compare to As-Is Products (Capability-Oriented)
6. Analyze Use Cases – Did We Capture It All?

Problem Identification

1. **Isolate the Primary Problem**

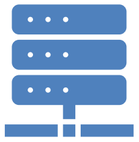
Start with the end-state or current state, and isolate the primary problem

- **From End State –** This could be a statement, “I want to do X more efficiently, in larger quantities, to add capacity, or to add a completely new capability that I cannot do now.”
- **From Current State –** This could be a statement, “I cannot do X as efficiently, in as large a quantity, as quickly, or at all.”

2. Examine the Legacy System Challenge or Obstacle

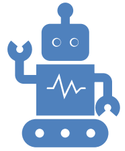
Examine the As-Is System and determine why you cannot achieve the end-state goal or **target**.

Is the problem or obstacle needing a new technology or capability?



Need to collect data or connect with another data source?

Process change?



System Automation or Efficiency?

Problem Identification

3. **Analyze the Underlying Problems**

After examining the surface or primary obstacle, determine if there are more obstacles to the end-state, a sequence of required changes, or other underlying problems.

Assume you solve the primary problem and define how.

Then, examine the As-Is process and system with this change to determine if you can achieve the end-state goal.

If there are still obstacles, list them.

4. Map out the As -Is State (Process Oriented)

If the systems is “Process Based,” consider creating a process map.

Apply Value Stream Mapping by creating As-Is Process map from end-to-end and identify process step obstacles which new system would eliminate.

Draw alternative solution “To-Be” process maps, compare the two maps side-by-side, and validate intended end-state would be achieved.

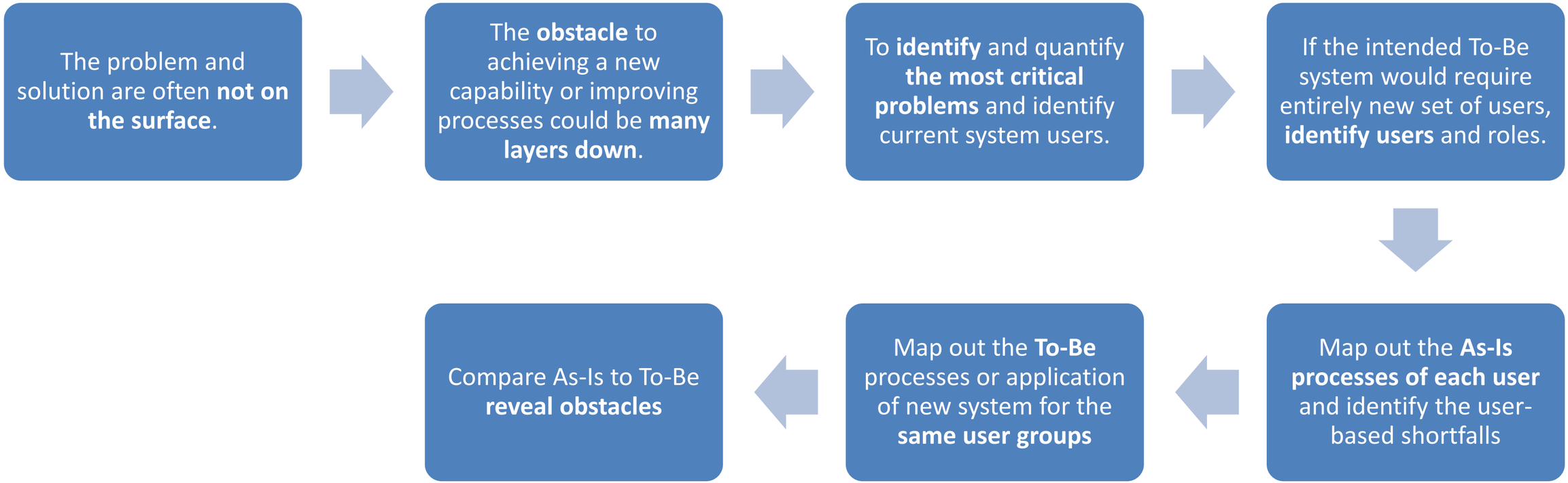
Problem Identification

5. List End-State Goals and Capabilities and Compare to As-Is Products (Capability-Oriented)

- Define where the As-Is capability falls short
- List the required changes to systems, products, and personnel to achieve new capability.
- Identify alternative solutions to achieve the new capability
- What changes need to be made to the As-Is system to achieve intended capability?
- At high level, define the sequential development and implementation steps required to change existing system to a new one with the required capability.

Problem Identification

6. Analyze **Use Cases – Did We Capture It All?**



Shortfall Categorization

By understanding and categorizing the incremental shortfalls versus the end state, we can list the shortfalls into quantitative classifications and make it easier to measure and quantify them.

Shortfall Categories
Cost
Capacity or Scalability
Infrastructure
Environmental
Business Processes/ Operational Processes
Data and Information
Productivity
Quality
Efficiency
Effectiveness
Obsolescence and Sustainability

FAA Safety Business Case Categorization

In the table, we list the following:

- Shortfall Capability
- Shortfall Classification
- Program Phasing
- Traceability – Basis
- Traceability – Shortfall Description

Shortfall Traceability Matrix presents shortfalls in an organized and quantifiable means:

- Provides details for each end state capability
- Defines each category and how it will be applied during implementation
- Defines basis of shortfall

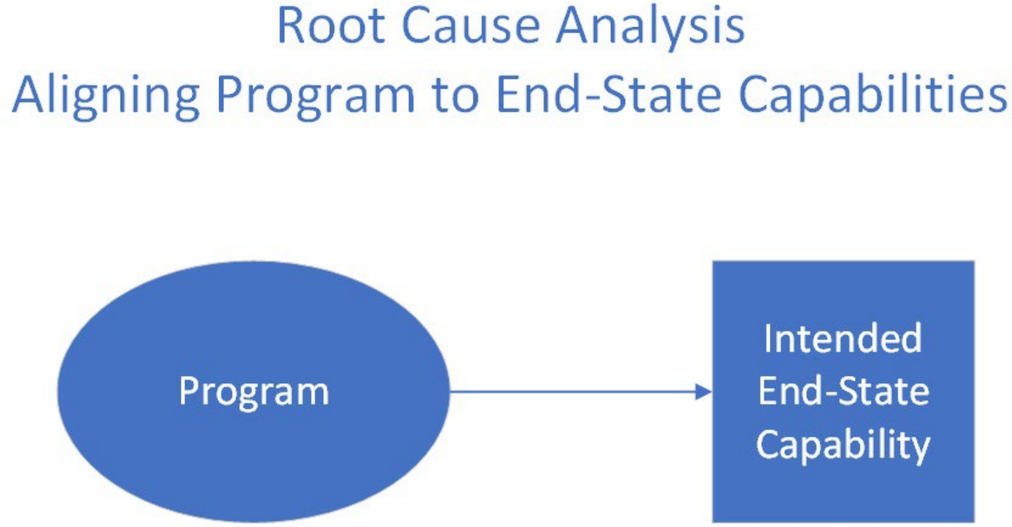
Agency Safety System Shortfall Traceability Example

	Name	Shortfall Classification			Implementation Phase				Shortfall Traceability	
ID	Shortfall Capability	Productivity	Efficiency	Effectiveness	1	2	3	4	Basis	Category Description
1	Safety Quality Process		✓	✓	75%	25%			- Based off Agency Strategic Plan - Ties to proposed Safety System end-state objective #1	**Efficiency & Effectiveness** - Safety program will increase efficiency automating processes for safety analysts and providing data that would normally be a time-consuming manual process. - Safety program will increase effectiveness by helping analysts make easier correlations between safety data and by providing additional filterning criteria for historical events.
2	Safety Collection & Analysis			✓	30%	25%	25%	20%	- Based off Agency Strategic Plan - Ties to proposed Safety System end-state objective #2	**Effectiveness** Improved availability, consolidation, and standardization of data in Safety System will facilitate safety analysts understanding of similar events and allow for correlations to help determine causality. Analyzing and focusing on historical events will improve impact analysis and be a more effective analysis technique.
3	Risk Analysis Process	✓	✓		25%	40%	25%	10%	- Based off Agency Strategic Plan - Ties to proposed Safety System end-state objective #3	**Efficiency & Productivity** **Efficiency -** When the safety analyst designates an event in one system, it will be correlated in other anlaysis systems for the same historical event. This will save time and manual research to draw conclusions about events. **Productivity -** The analysts will be able to process more volume of events to analyze using the automated and integrated system.

Shortfall Analysis Process Steps

Root Cause – Shortfall Quant.

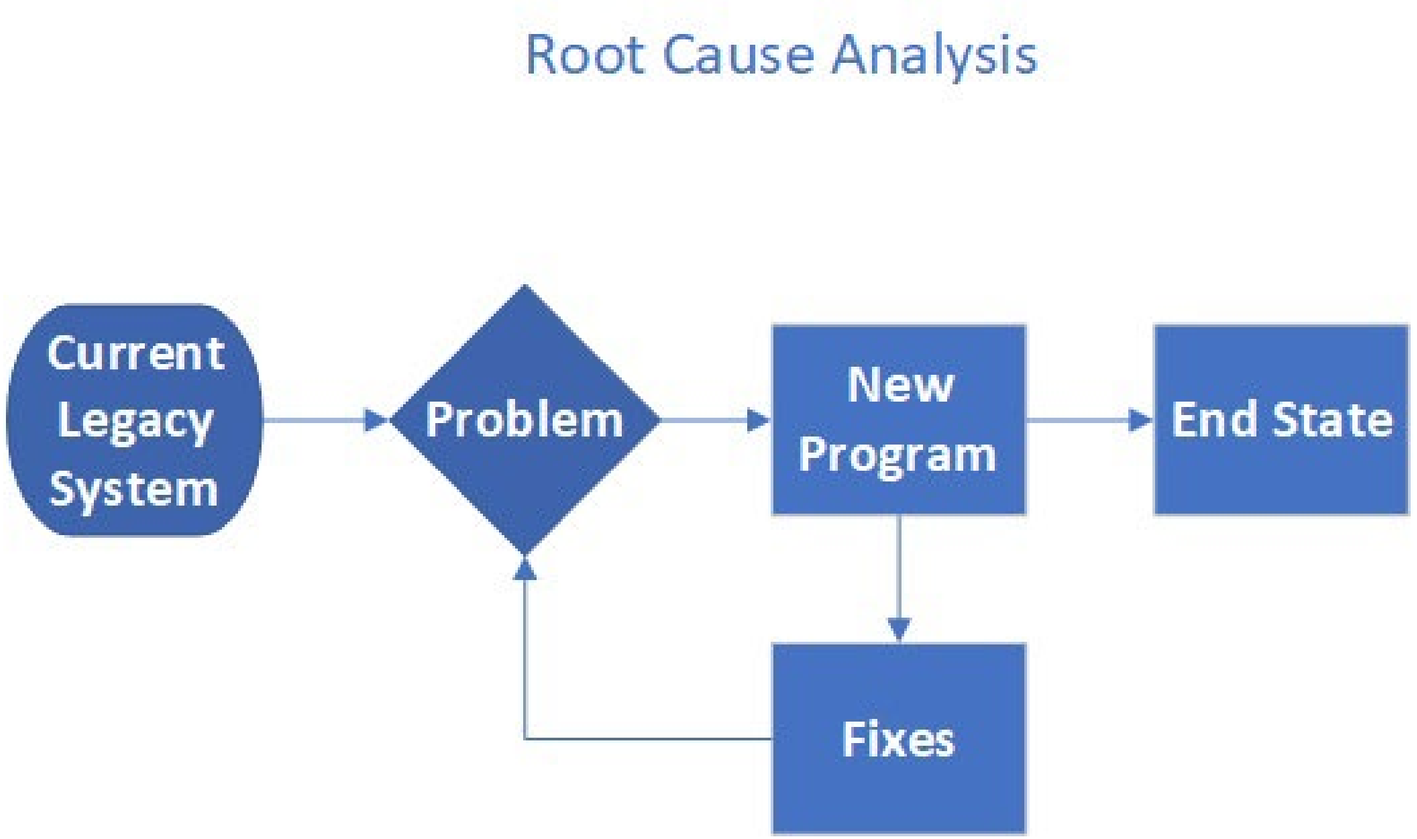
- Articulating and measuring the impact of a shortfall is much more difficult than defining the program objective.
- Root Cause Analysis is a technique analysts can use to dissect a problem and trace it back to the origin of the problem.
    - Often used to identify the cause of a problem, like a system outage.
    - Provides program office a means of fixing the primary problem
    - Helps us measure the impact of a shortfall by identifying and examining critical use cases with large quantification value.



- 1st Step – Root cause analyses helps the team define the program objectives by the intended end-state capabilities the agency wants to achieve.
- After program implementation, what new capability, improved system or process, or continued service will the agency deliver.

Root Cause – Shortfall Quant.

- The team will then examine how the new capital investment will resolve the shortfall that persists with the legacy system.
- Even in initial analysis, solution should be comprehensive to the problem the agency is trying to solve.
- If the solution only solves the first problem the team can identify, the investment may only solve part of the shortfall and may not help agency achieve its end-state objectives.



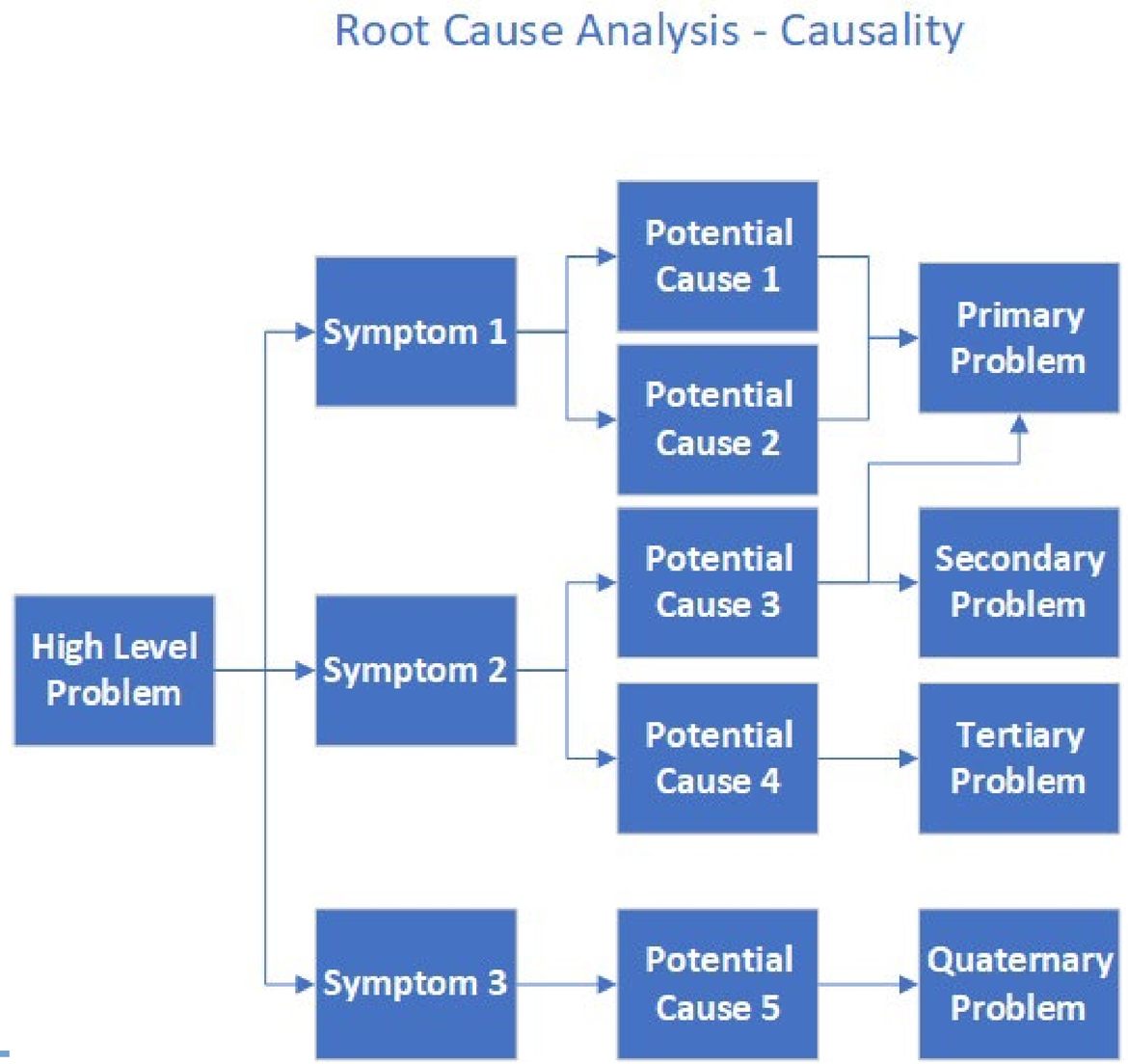
Root Cause – Shortfall Quant.

- To achieve an intended agency objective and program end-state capability, program office needs to:
  - Uncover each impacted user and use case in the legacy system,
  - Understand the underlying constraints,
  - Trace the *symptoms* of the problems back to each potential origin or cause,
  - Identify the primary problem the investment needs to solve

In traditional root cause analysis, the analyst:

1. Identifies the initial and high-level problem,
2. Lists problem symptoms,
3. And brainstorms and investigates potential problem causes to find the root cause.

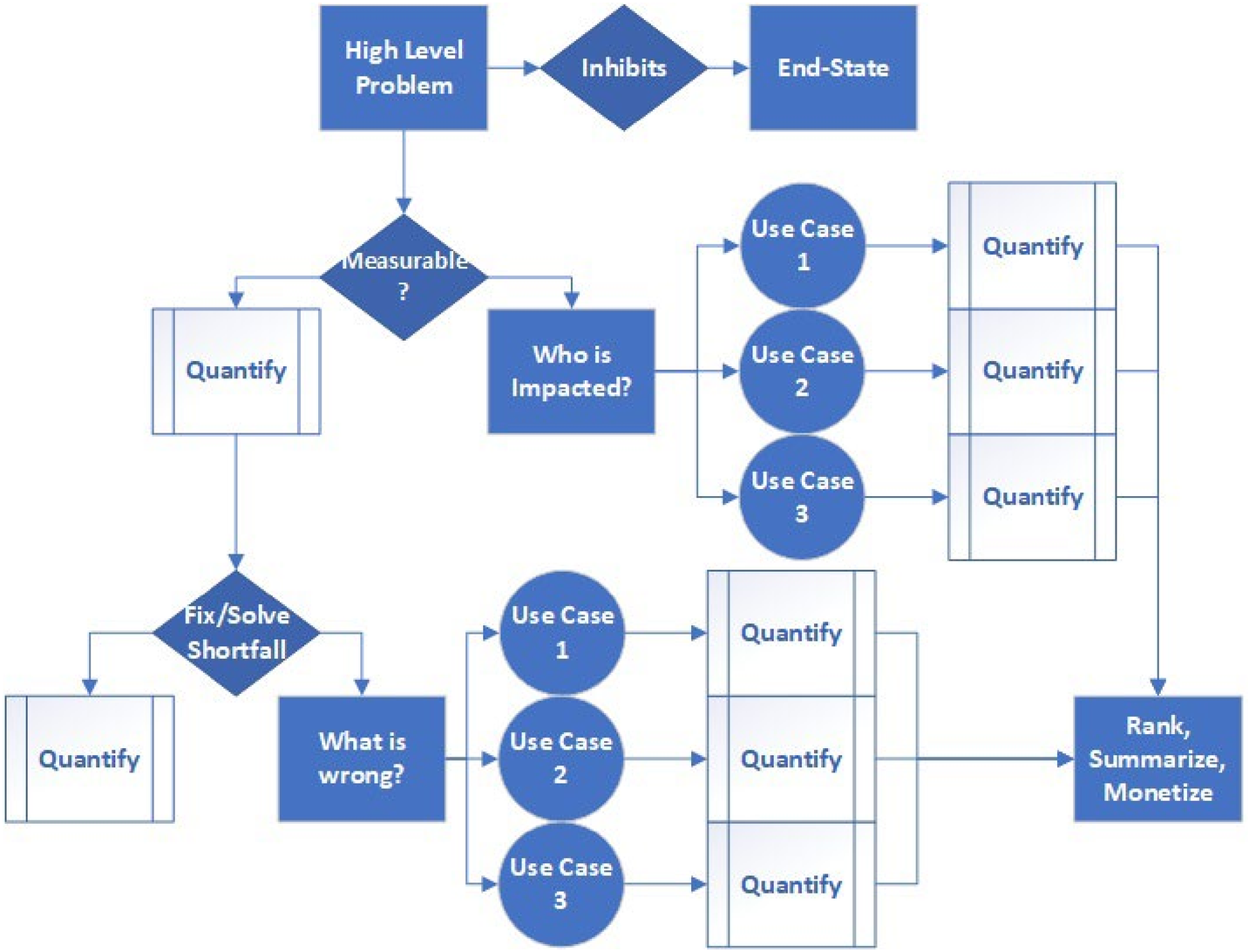
For shortfall analysis, we use root cause analysis to identify shortfalls at the use case level that we can quantify and demonstrate monetizable value.



Root Cause – Shortfall Quant.

- After the team lists each of potential root causes and identifies multiple shortfalls, they can assess whether the discovered shortfalls and legacy use cases are quantifiable.
- If quantifiable → team can categorize and quantify the shortfall.
- Once the shortfall is quantified, the team should reassess and determine if shortfall solution solves the full problem and enables the end-state.
- If not, team can examine what is still wrong with the legacy system and why it does not provide a comprehensive solution.

- **Use Cases** – By modeling use cases, can identify the remaining underlying problems or root causes and quantify those shortfalls. After identifying all primary shortfalls in the root cause analysis, program office should:
  - Categorize
  - Monetize
  - Catalogue the shortfalls



Impact Analyses

- In the impact analysis, team examines use cases to measure impact of the persisting problem on users.

Inefficient Process Shortfall

- If problem is an inefficient process, team can conduct a time study to measure the current time it takes to complete a tasking or analysis. Using Business Process Reengineering or Value Stream Mapping, the team can measure the equivalent duration to complete the tasking or analysis in the To-Be case.

Sustainment Shortfall

- If problem is the inability to sustain a system past a specific date due to parts obsolescence and system End-to-Life (EOL), the analyst can conduct a sustainability analysis study, estimate the date of End-of-Service (EOS), and quantify the impact of the end date.
- To monetize the impact of EOS date, analyst needs to estimate the "consequence" of that adverse end-result.
- **Quantify the Shortfall** answering:
  - What is the impact of **not** making the investment?
  - How can we measure the "consequence" of **not** making the investment or acquisition?

What is Value Stream Analysis?

Value Stream Analysis Purpose

- Shortfall analysis tool to measure process improvement
- Study, map, and analyze current processes and steps from end to end.
- Identify way to improve process through automation, data integration, system consolidation, more powerful analytical capabilities, or some other means.
- Eliminate ***non-value-added*** process steps and streamline processes to ***reduce waste*** in the system and maximize value.

Value Stream Mapping

- Before we conduct value stream analysis and establish a means of measuring and eliminating waste in a current business process, we map out the processes we plan to examine.

Value Stream Mapping (VSM) Steps

Step 1 – Create VSM Team

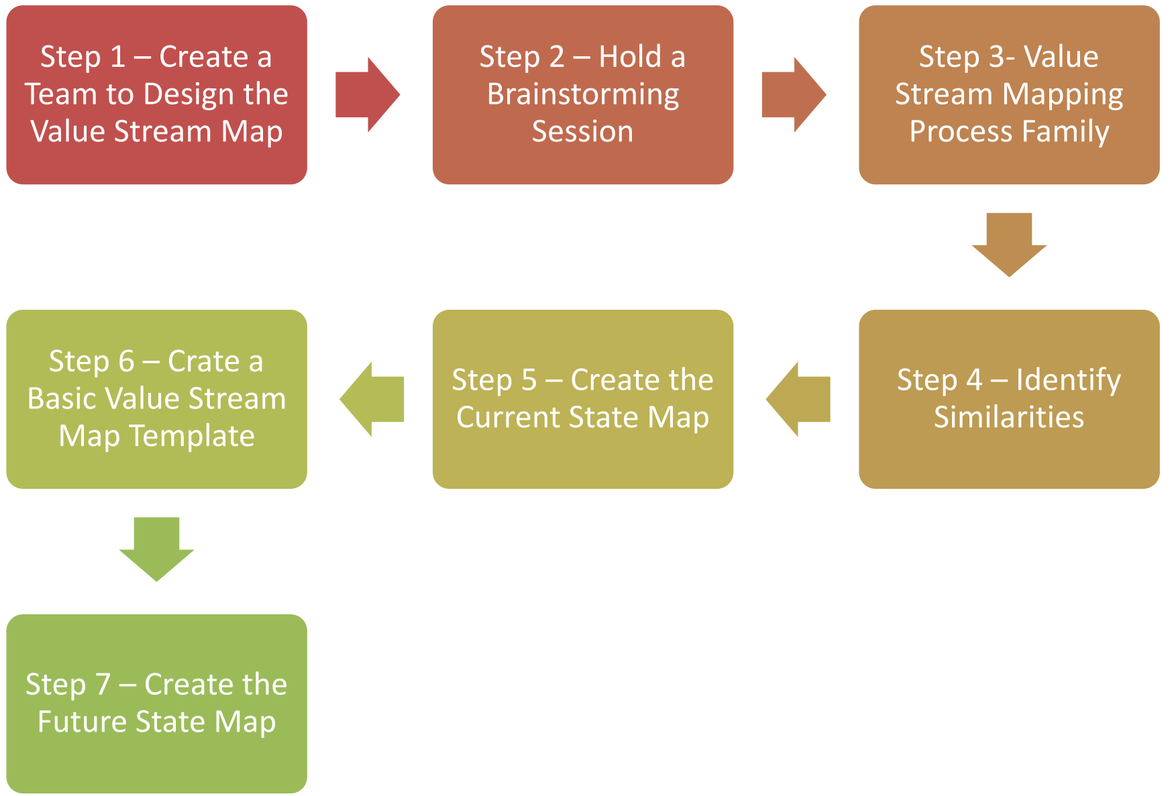
- Team members should include users of the current As-Is process and subject matter experts who can articulate the current state and process.
- Include variety of users to capture and isolate all the primary As-Is process steps and estimate duration or quantity.

Step 2 – Brainstorming Session

- In brainstorming session, team will define the problem being solved, existing process, identify and define users and use cases, and draw out all the process steps in the current business process.
- Collectively map out the To-Be process, step-by-step in a process map, defining future state that solves the shortfall.

Step 3 – VSM Process Family

- Create matrix that maps and documents the process steps.
- List the process steps sequentially on one axis.
- List products impacted or time study on the other axis.



Value Stream Mapping (VSM) Steps

Step 4 – Identify Similarities

- Identify similar steps that may be material in a time study, but which can be consolidated into a streamlined series of process steps.
- Allows team to focus on unique steps that can be reduced in To-Be case and helps team identify and isolate non-value-added steps during the As-Is analysis

Step 5 – Create Current State Map

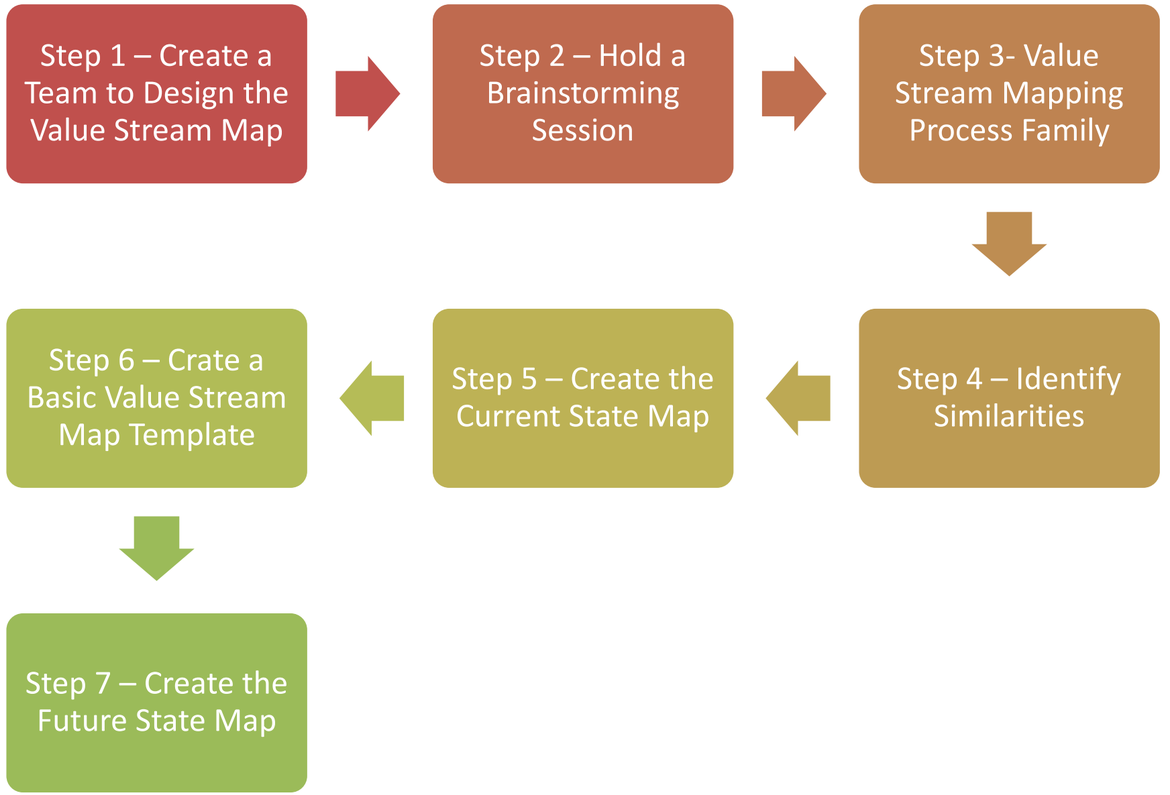
- After identifying all process steps and quantification metrics, team maps out sequential steps for the As-Is process.
- For quantification, team will note only units like volume, cycle time, inventory, or any time study measure

Step 6 – Create Value Stream Map (VSM) Template

- VSM Template should capture how team will quantify the steps and measure waste.
- Teams set up means of measuring each task of the user, scenarios, and a time study template, allowing team to calculate the duration of each step in the VSM, including risk.

Step 7 – Create Future State Map

- Create To-Be process map, determining how program solution would streamline processes and eliminate individual steps.



Case Study – FAA Maintenance Logging Process

Shortfall Analysis –Case Study

- FAA conducted investment analysis for a major maintenance logging system capital investment.
- Program designed to solve shortfalls centered around a legacy software system and the agency's portfolio objectives of enhancing predictive maintenance capabilities and Reliability Centered Maintenance (RCM).
- End-State Objective was:
    - A streamlined and integrated maintenance system in the FAA's supply chain
    - Allowing for improved:
        - Flow and utilization of data
        - More efficient processes
        - Response times for infrastructure sustainment
- With better recording and data sharing, FAA could be more proactive in its maintenance and repair planning.

- In Step 1, program office "aligned" program to intended end-state capabilities and objectives. The next step of investment analysis is to "define the problem" and identify the primary shortfalls.

Shortfall Analysis –Case Study

Step 2 – Problem Definition

- The infrastructure and enterprise architecture of Maintenance Logging:
  1. Reduced the integrity of maintenance data
  2. Did not provide timely situational awareness to field maintenance personnel and stakeholders impacted by maintenance events
  3. Impeded the ability of personnel to perform predictive maintenance activities.
- Shortfalls impacted the ability of the agency's maintenance system to improve efficiency and to apply organizational end-state goals of the Reliability Centered Maintenance (RCM) and data-driven decision-making initiatives.

Steps 1-4

- After (1) program alignment to organizational goals and program end-state, the shortfall analysis team (2) defined primary legacy system shortfalls, (3) isolated the shortfalls into multiple use cases and challenges, and (4) applied shortfall categories for each shortfall as depicted (right).

Program Shortfalls

"Define the Problem"

"Isolate the Shortfall" | "Apply Categories"

- **Redundant Logging** (Efficiency) – Inefficient time and wasteful cost for duplication of data entry activities which required validation.
- **Manual Data Entry Errors** (Quality) – Without automation, reliance on unintegrated systems and manual data entry resulted in data errors.
- **Delays** (Effectiveness) – Unintegrated systems caused delays in planned and unplanned maintenance event coordination and resolution.
- **Absence of Situational Awareness** (Data and Information) – With integrated systems, maintenance data transparency could be improved.
- **RCM** (Inefficiency, Data) – Unintegrated systems provided less effective Reliability Centered Maintenance (RCM) capabilities.
- **System Integration** (Efficiency) – Without some interfaces to external systems, maintenance notification process time took longer, including manual coordination.
- **Maintenance Restoration Delays** (Capacity, Inefficiency) – Manual processes and time-consuming logging delayed restoration of NAS equipment and services, potentially impacting airspace operations.

Prob. Def., Isolation & Categorization

To categorize and prepare a quantification strategy for each of the primary shortfalls, the shortfall team developed a shortfall matrix to list out the plan for the business case. Then, the team prioritized the shortfalls and established a methodology for quantification of the maintenance logging process, establishing a Maintenance Logging Value Stream.

Shortfall Category	Shortfall	End-State Objective	Description	Quantification Approach
Efficiency	Redundant Logging	System Integration and Automation to reduce maintenance logging time	Utilizing different legacy logging systems, maintenance tracking and field teams record duplicate maintenance logging entries without transparency to each other's logs, increasing the time for maintenance event resolution.	Value Stream Analysis Time Study
Quality	Manual Data Entry Errors	Incremental system interfaces and system integration will result in fewer manual entries and greater data fidelity	Without integrated internal logging systems and external system interfaces, maintenance personnel record logs manually, copying and pasting data from one system to another, sometimes resulting in errors.	Value Stream Analysis Time Study
Effectiveness	Delays	Incremental system integration to improve efficiency	Unintegrated Systems can cause delays in planned and unplanned maintenance event coordination	Value Stream Analysis Time Study
Data and Information	Absence of Situational Awareness	Increased situational awareness for Maintenance and Logistics community	With integrated systems, maintenance data transparency could be improved	Value Stream Analysis Time Study
Inefficiency & Data	Reliability Centered Maintenance (RCM)	Increase application of RCM Capabilities	Multiple systems used to track and record maintenance logs can impede data transfer and slow RCM application	Value Stream Analysis Time Study
Efficiency	System Integration	With increased external system integration, can reduce time of maintenance restoration	Without some external interfaces, maintenance logging requires more manual entry and validation.	Value Stream Analysis Time Study
Capacity & Inefficiency	Maintenance Restoration Delays	Restore Airspace Sooner	Manual processes and time-consuming logging delayed restoration of NAS equipment and services, potentially impacting airspace operations	Constrained Airspace Maintenance Event Monetization

Value Stream Analysis

- The maintenance logging business case was primarily centered around process improvement and efficiency with:
  - System integration
  - Data exchange
  - New system capabilities
- **As-Is** – Team needed to better understand current maintenance logging processes and how to change and improve the process as it added functionality and automation.

- **Value Stream Analysis** – To identify all the process shortfalls, root causes, and the magnitude of these shortfalls, the team conducted a Value Stream Analysis, starting with a Value Stream Map of the As-Is processes end-to-end.
  - To trace the steps of maintenance logging, the shortfall analysis team met with user groups across multiple facilities to collect and observe the series of steps the teams take to record, log, track, and resolve maintenance events for the FAA.
  - **Value Stream Map** – By getting broad spectrum of users, team established comprehensive list of sequential process steps under different circumstances and scenarios and consolidated those steps into a quantitative Value Stream Map.
  - **Time Study** – The team identified, traced, and developed flow diagrams for 36 As-Is maintenance event logging process steps and added influence diagrams to demonstrate sub-steps and differences in maintenance logging based on shift and time of day.

Value Stream Analysis

- **Quantification**
  - **As-Is Time** – To quantify the value stream, shortfall team conducted a time study, gathered frequency of event data from historical databases, and interviewed subject matter experts (SMEs) to record average durations for each step.
  - **Facility Volume** – Added volume with number of facilities and number of maintenance events each year. Extrapolated time study to quantify the total duration from end-to-end of maintenance event, by facility and facility type. As-Is process was an objective quantitative approach for measuring current maintenance logging.
  - **To-Be Time** – After estimating the duration of individual maintenance event logs for the As-Is state, team met with additional facility maintenance SMEs and with logistics integration SMEs to estimate the potential savings per event for an average low and average high and ran a Monte Carlo Simulation to get a full risk distribution.

- **Results** – Applying the risk adjustment, team estimated that the time savings of maintenance logging per event across the NAS compared to the As-Is case was more than 50 minutes.

Value Stream Analysis

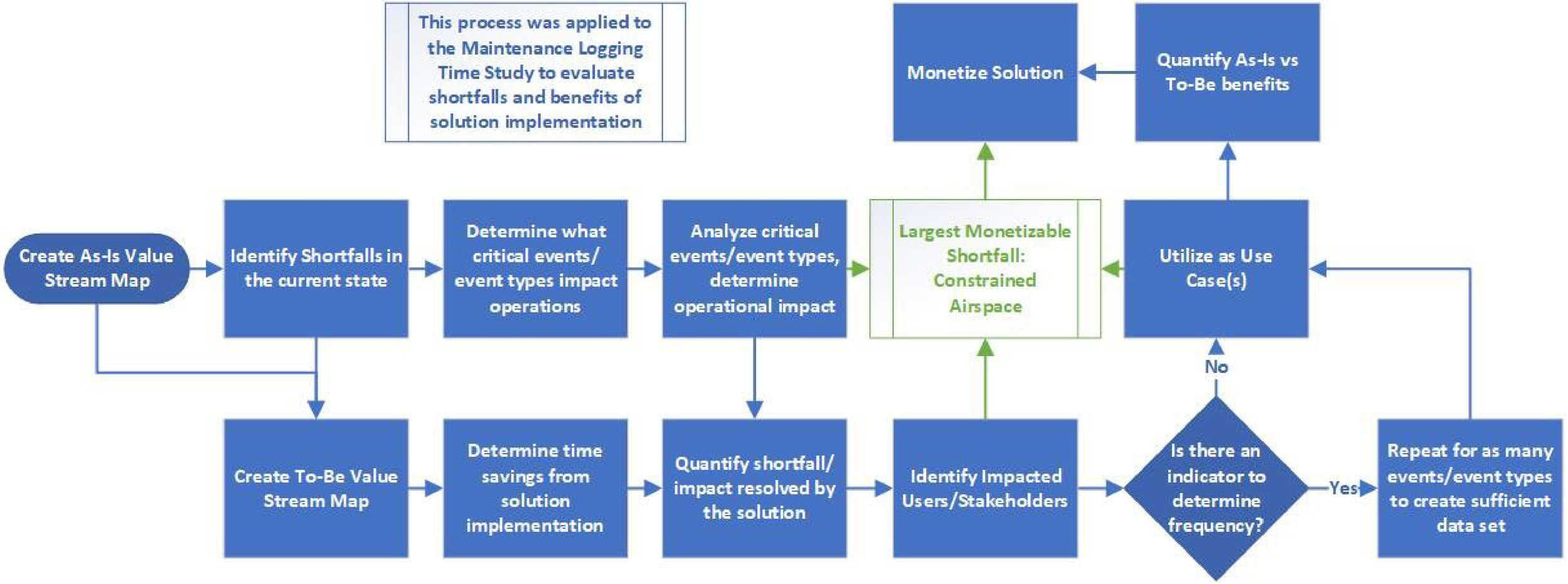
Using hypothetical data, the table displays the first seven steps of the Maintenance Logging Value Stream Analysis time study, highlighting the structure of the value stream steps in the As-Is process map and associated durations for each event in the As-Is and To-Be processes. In some cases, the To-Be step is eliminated completely.

Value Stream Time Study Steps		Maintenance Logging Value Stream							
		As-Is Avg (Mins)			Predicted Percentage		To-Be		
		Maintenance Center 1			Reduction		Maintenance Center 1		
		Low	High	Avg	Scheduled	Unscheduled	Low	High	Avg
1	MANUAL - Maintenance Analyst calls Control Tower to confirm	2.00	3.50	2.75	75%	20%	0.77	1.35	1.06
2	MANUAL - Failure Confirmed				0%	0%			
3	MANUAL - Maintenance Center logs in failure event in System 1	2.50	4.00	3.25	25%	25%	1.88	3.00	2.44
4	MANUAL - Maintenance Center determines if NOTAM (indicator) is required	1.25	2.50	1.88	45%	10%	0.80	1.59	1.20
5	MANUAL - Maintenance Center analyst logs into System 2	1.00	1.50	1.25	100%	100%	-	-	-
6	MANUAL - Maintenance Center analyst logs details into System 2, enters in System 3	2.50	4.00	3.25	75%	75%	0.63	1.00	0.81
7	MANUAL - Maintenance Center analyst publishes NOTAM (indicator)	0.25	0.50	0.38	100%	100%	-	-	-

Impact Analysis & Monetization

- Since the shortfall analysis team could not monetize the time savings per maintenance event or prove the business case via cost/benefit analysis, it needed to explore the secondary use cases downstream of the maintenance logging value stream analysis.
    1. How could the team monetize these program efficiencies?
    2. How would we translate the time savings into dollars and value?
- Program Office needed means of monetizing program value with a tangible use case.
- Identified means of monetizing value to the agency, airlines, and the flying public (primary FAA stakeholders).
- **Problem Identification & Value Stream Analysis** – Team examined purpose of process efficiencies and answering the question, “So what?” after identifying time savings in the value stream.
- **Root Cause Analysis/ Impact Analysis** – Team discovered that resolving maintenance events faster could have a material impact on flight operations. We could now relate the time series value stream to agency operations and stakeholder value.
- **Value Proposition** – During an unexpected system outage, some systems will impact flight operations, causing flight delays, cancellations, and other measurable impacts to the airspace.
    - Agency has indicators which can help organizations identify which systems can cause flight delays.
    - Using historical flight data, team measured the flight impact of event-specific system outages and quantified the incremental impact. The team collected equipment and event-specific outage data and quantified the outages, extrapolating the data, and monetizing the value using FAA metrics.

Impact Analysis & Monetization



It is important to note that without an impact analysis, the shortfall team might not have correlated that the largest shortfall value was an extrapolation of the value stream and related to flight operations. Not all shortfalls are on the surface, and it is important to examine all underlying use cases in an impact analysis.

Conclusion

Conclusion

- To **creatively quantify critical investment shortfalls** and define business case value, analysts use proven shortfall analysis strategies and processes, including:
  - **End-State Analysis** to align the problem statement with required program end-state capabilities,
  - **Root Cause Analysis** to identify primary shortfalls and their root causes,
  - **Impact Analysis** to quantity the underlying use case shortfalls,
  - **As-Is Versus To-Be Modeling** to quantify incremental value,
  - **Value Stream Analysis** to map process dependencies and isolate shortfall waste.

- With a crowded program management field of new investments, infrastructure sustainment acquisitions, and constrained capital budgets, agencies need creative approaches to shortfall quantification and business case justification.
- Without robust shortfall and business case benefits quantification, cost/benefit analyses may be inadequate to justify business cases and secure needed F&E funding, risking investment delay or cancellation.

Backup