

Exceptional service in the national interest



System Analysis Environment

Yesterday, Today, & Tomorrow

Presenter: Megan Merewether
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Outline

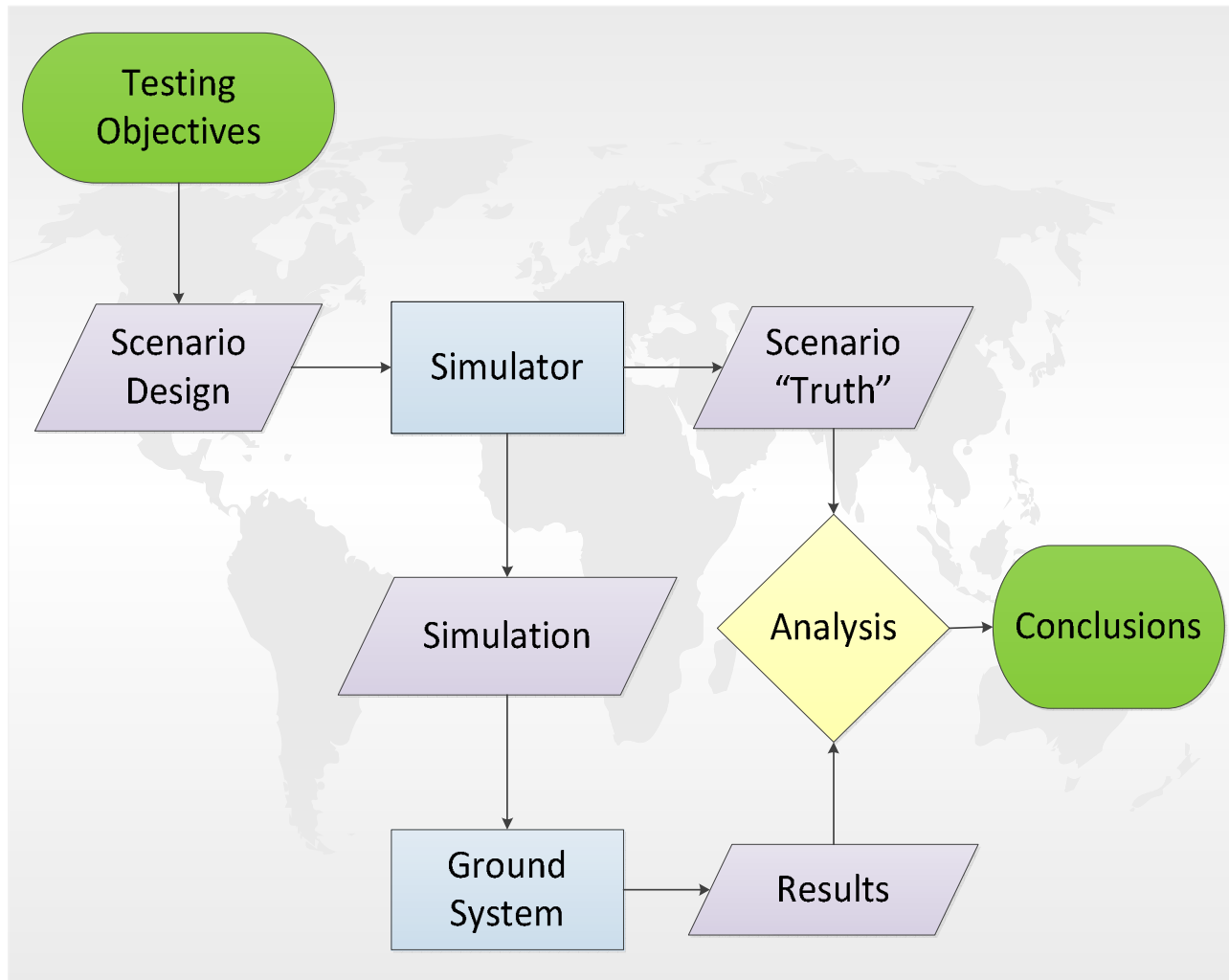
- Overview
- Yesterday
 - Automated Answer Checker (AAC)
- Today
 - Ground System Performance Analysis Tool
- Tomorrow
 - System Analysis Environment

Overview

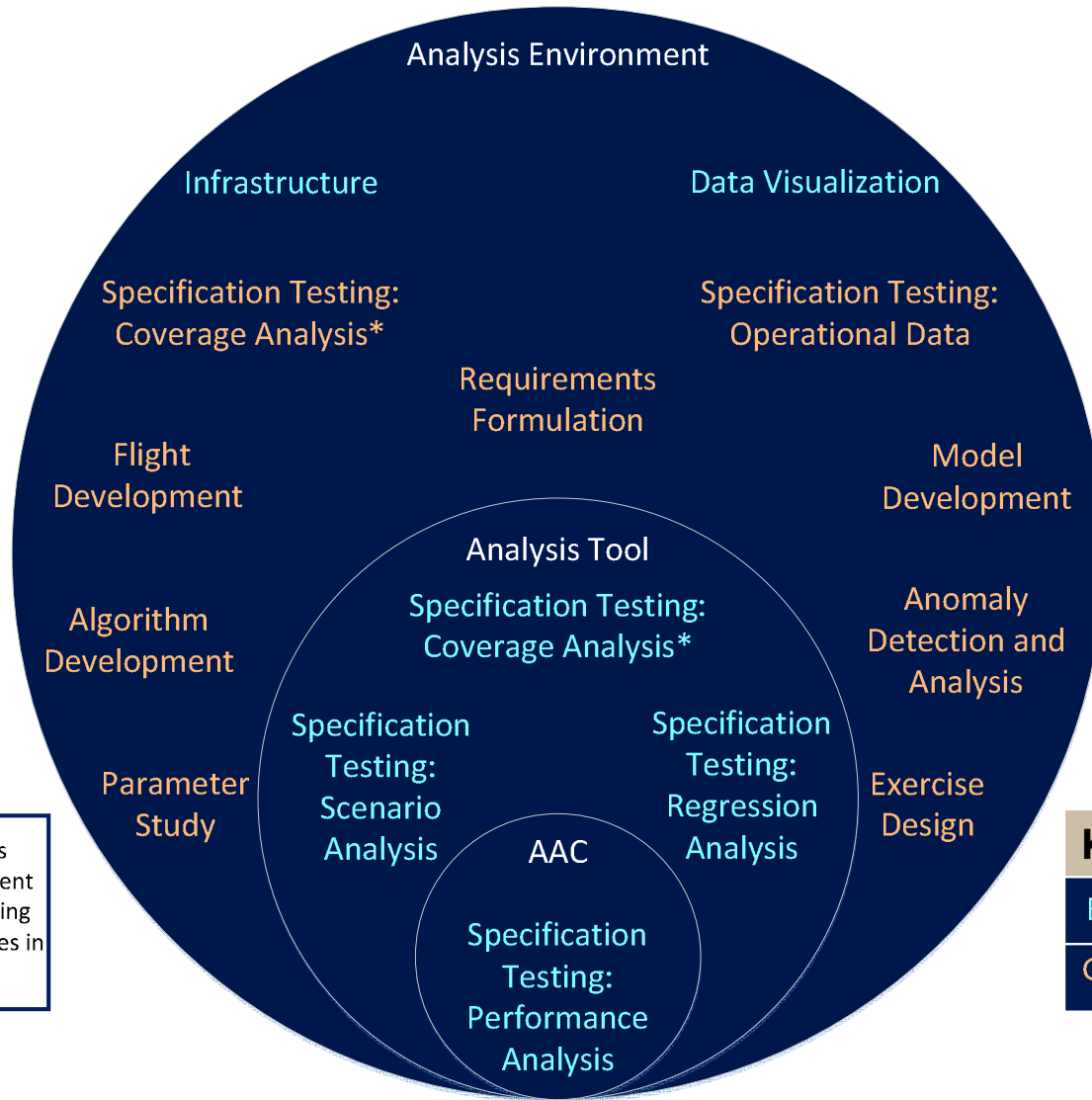
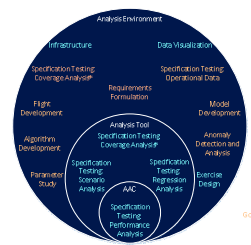
- The system has explicit **performance requirements**
 - To ensure **adherence to these requirements**, a method of acquiring, analyzing, and summarizing the data must be implemented
 - System Analysis Tool is a **deliverable product**, installed on the maintenance node of the operational system

- Analysis Software Life Extension
 - Infrastructure – As the system undergoes **technological life extensions**, the method of testing and analyzing the system must evolve with them
 - Necessary Improvements – **Limitations** of the Analysis Tool must be addressed in order to implement an up-to-date Analysis Environment to analyze the system
 - Enhancements – **Additional capabilities** and improvements in **user flexibility** allow for a **broader usage**

System Overview



Capabilities



*Note Coverage Analysis is extremely limited in the current analysis tool. We are proposing expanding on those capabilities in the Analysis Environment

Key:

Essential Objectives

Goals

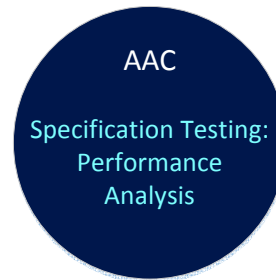
Automated Answer Checker (AAC)

YESTERDAY

AAC Scope

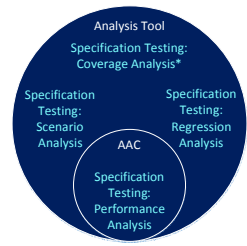


- **First** system to analyze **ground system performance** by comparing results to **“truth” values** produced by a scenario simulation
- Used for over a decade during **ground system Build 3 and Build 4**
- **Limited specification testing** consisted of analyzing system performance against system requirements



AAC Functionality

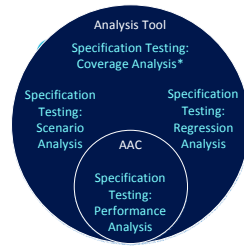
- **Command-line program** with a plethora of options, depending on each scenario
- Very few analyses of data
- **No graphics**
 - Visual representation of data done in viewgraphs
- User could **not easily identify errors**
 - Must parse through files to find errors manually



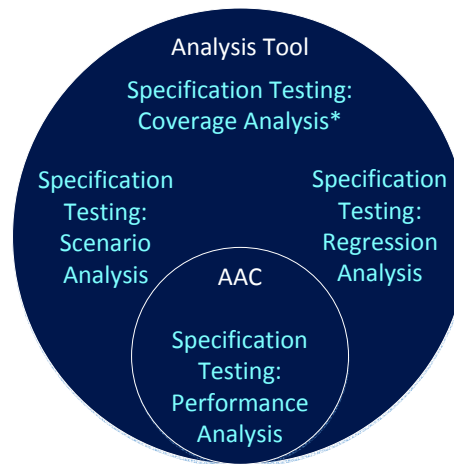
Ground System Performance Analysis Tool

TODAY

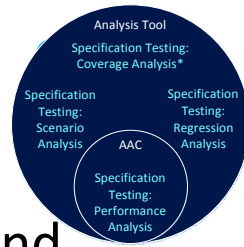
Scope



- Like AAC, the Ground System Performance Analysis Tool compares what actually occurred (“truth” as defined in scenario design) to what the ground system reported
- Determines which, if any, requirements apply, and determines if the requirements were satisfied
- Expands on AAC by providing **scenario analysis, coverage analysis, and regression analysis**

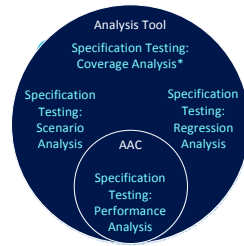


Functionality



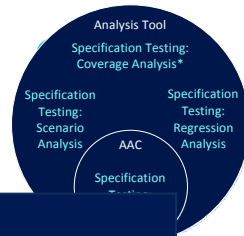
- Provides **automated, reliable testing** and **analyses** of the ground system
- Compiles statistical data, providing: performance analysis, scenario analysis, coverage analysis, and regression analysis
 - Limited **anomaly detection** aids
 - Limited **visualization utilities**
- Option for analyses to be run as a **batch**
- Pull-down menu of available test sets allows the user to select previous data to compare with the current set (**regression testing**) or to combine with the current set (**consolidating results**)

Inputs

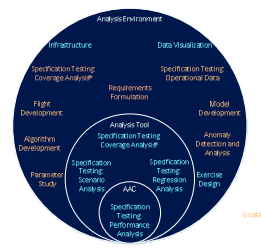


- Ground System Analysis Tool must access three main types of inputs:
 - Simulation “truth” values
 - Obtained from three file types
 - Ground System estimates
 - Analysis Tool configuration files

Analysis Tool Functionalities



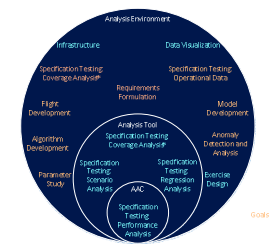
Function			System/Application			
			AAC		Analysis Tool	
Category	Sub-Category	Description	Simulation	Operational	Simulation	Operational
Specification Testing	Coverage Analysis	Analyze system requirements coverage	--	--	X	--
	Performance Analysis	Analyze system performance against system requirements	X	--	X	--
	Regression Analysis	Analyze system performance changes	--	--	X	--
	Scenario Analysis	Analyze scenarios for potential spec hits, characterizing scenario, etc.	--	--	X	--



System Analysis Environment

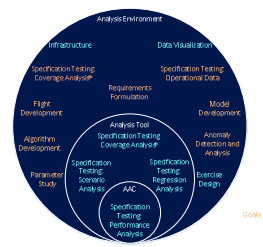
TOMORROW

Motivation



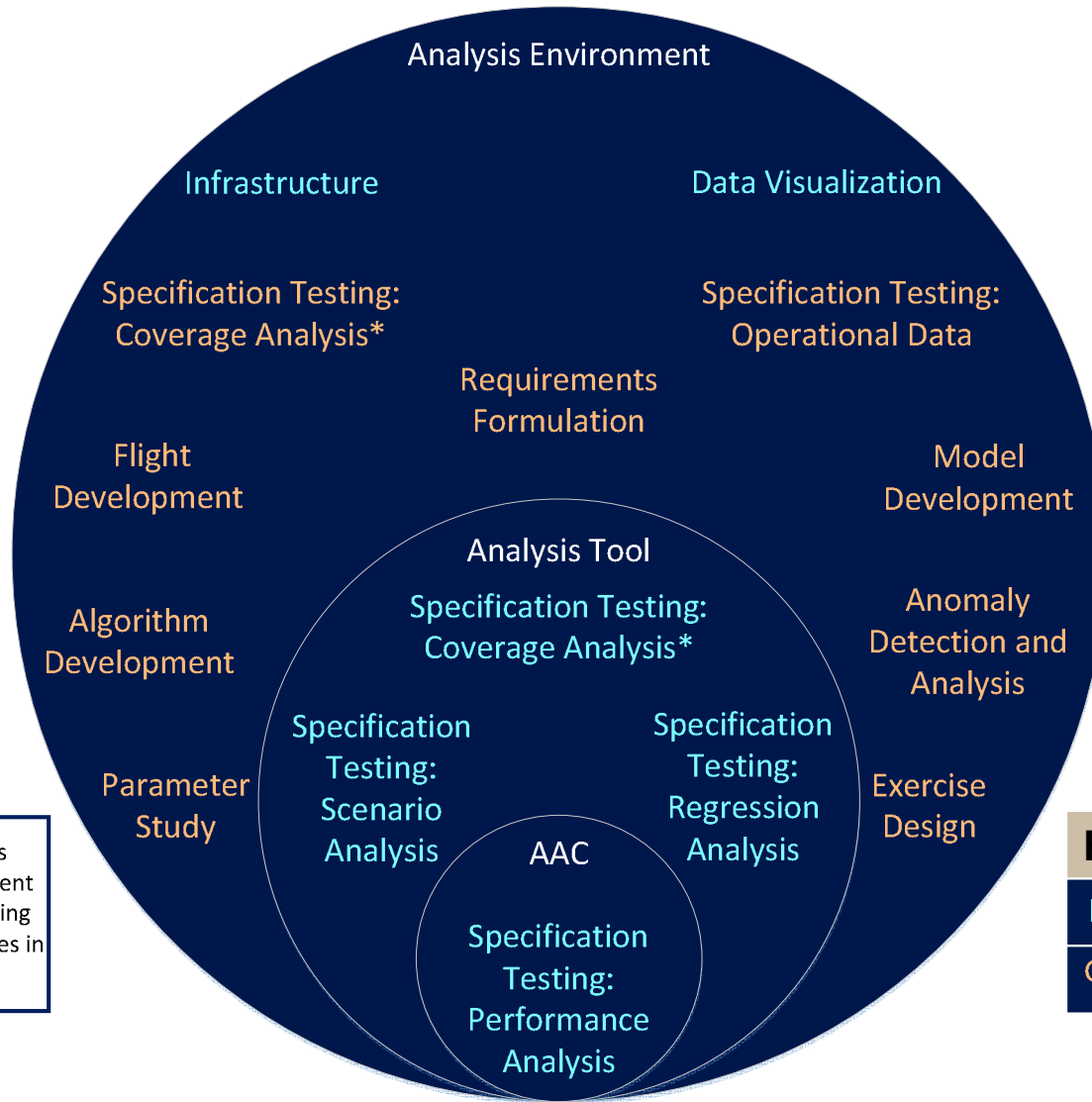
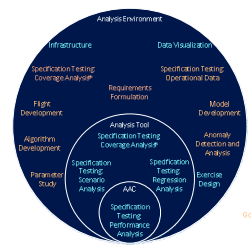
- Infrastructure
 - Ground system and Simulation Program are each pursuing **technological life extensions**
 - Analysis Tool requires inputs from both systems, so it must evolve with them
 - **Interfaces** need updating
 - **Architecture** needs to be modernized
- Necessary Improvements
 - Analysis Tool is **driven by specs** outlined by Ground System
 - **Bug shortcomings** in software
 - **Inefficient**, both in software and analysis capabilities
 - **Lacking interconnectivity and consistency** of analyses
 - **Software practices** and **rigor**
- Enhancements
 - Develop an environment that operates on **simulation AND operational** data
 - Create an environment that is useful during **project development phases** (flight, ground algorithms, etc.)
 - Provide an environment that can be used **across the system program**
 - Increase **traceability, cohesion, and transparency** in all analyses

Objectives vs. Goals



- **Objectives:** Measurable, specific, and **non-negotiable** targets for the system to obtain
 - Update analysis system **infrastructure**
 - Address known **deficiencies**
 - Software rigor
- **Goals:** Intentions that go beyond objectives to incorporate additional desires for the system to achieve
 - **Enhancements** to Analysis Tool's current capabilities to allow widespread use of the system, improving **consistency** of analyses across the system

Capabilities



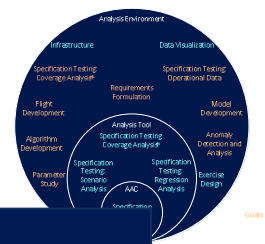
*Note Coverage Analysis is extremely limited in the current analysis tool. We are proposing expanding on those capabilities in the Analysis Environment

Key:

Essential Objectives

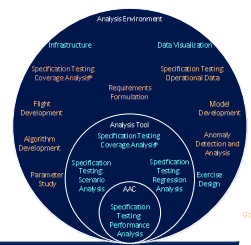
Goals

Analysis Environment Capabilities



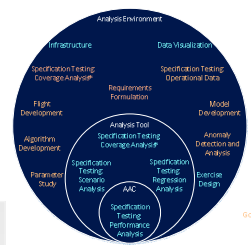
Category	Example
Infrastructure	Adapt to surrounding life extensions Improve storage and access to data, metadata, and analyses Update interface, correct bugs, improve flexibility, automate performance
Data Visualization	Ability to produce charts/plots for data Full life cycle visualization of sensor/algorithm response Full life cycle visualization of an event
Specification Testing: Coverage Analysis	For location accuracy, determine yield performance or identification performance Determine across all simulations if sufficient coverage is present without regard to how individual events performed
Specification Testing: Operational Data	Apply similar specification testing to operational data
Flight Development	Aid in formulation of new sensors or sensor commanding via "current vs proposed" analyses Aid in Verification & Validation efforts for flight development
Model Development	Aid in formulation of new model changes via "before and after" analyses Aid in Verification & Validation efforts for model development
Algorithm Development	Aid in formulation of new algorithm changes via "before and after" analyses Parameter space formulation Utilize extracted algorithm implementations from ground system Utilize analysis tools to operate on the data
Requirements Formulation	Aid in parameter space formulation for new requirements Achieve requirements formulation throughout System requirements flow
Anomaly Detection/Analysis	Examine trends/regression in various characteristics Employ automated statistical control theory to monitor state-of-health metrics, commanding, and performance
Parameter Study	Provide utilities for designing experiments Examine/formulate parameter space for mission studies and sensor studies
Exercise Design	Aid in design of high-fidelity exercises

Algorithm Development Environment

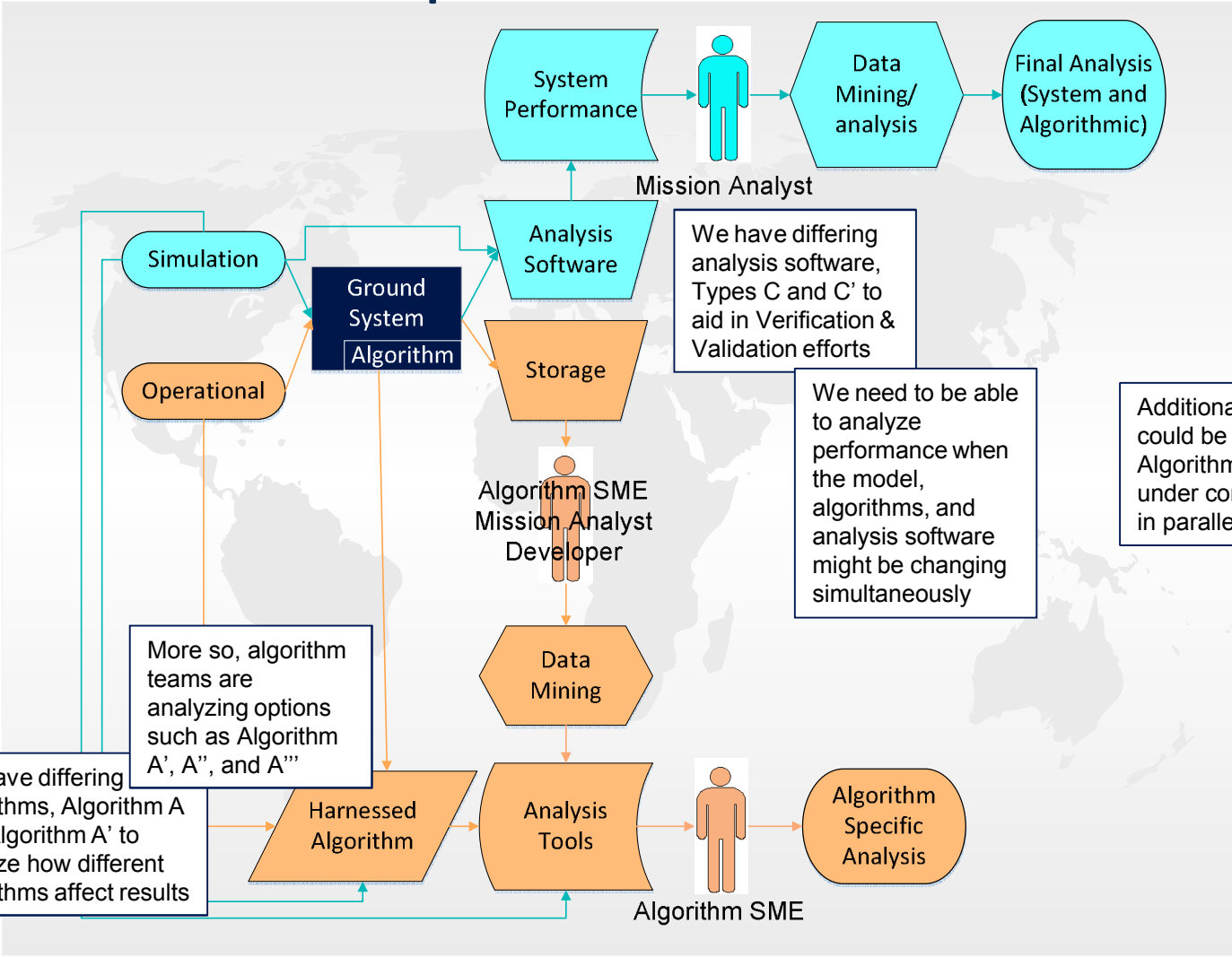


Function			System/Application					
			AAC		Analysis Tool		Analysis Environment	
Category	Sub-Category	Description	Simulation	Operational	Simulation	Operational	Simulation	Operational
Algorithm Development	Algorithm Development Analysis	Aid in formulation of new algorithm changes via "before and after" analyses	--	--	--	--	X	X
	Parameter Space Formulation	Aid in parameter space formulation for new algorithms	--	--	--	--	X	X
	Harnessed Mission Algorithms	Utilize extracted algorithm implementations from Ground System and utilize Algorithm SME analysis tools to operate on the data	--	--	--	--	X	X
	Verification and Validation	Aid in Verification & Validation efforts for algorithm development	--	--	--	--	X	X

Algorithm Development Environment



We have differing models, Model B and Model B' to analyze how changing aspects of the model affect ground system performance



We have differing analysis software, Types C and C' to aid in Verification & Validation efforts

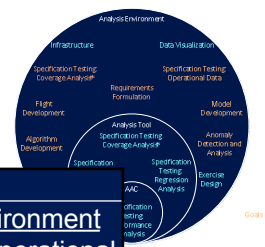
We need to be able to analyze performance when the model, algorithms, and analysis software might be changing simultaneously

Additionally, there could be changes in Algorithm D also under consideration in parallel

More so, algorithm teams are analyzing options such as Algorithm A', A'', and A'''

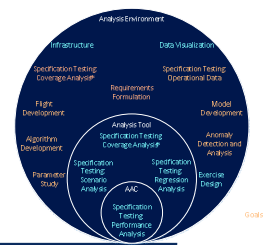
We have differing algorithms, Algorithm A and Algorithm A' to analyze how different algorithms affect results

Analysis Environment Capabilities



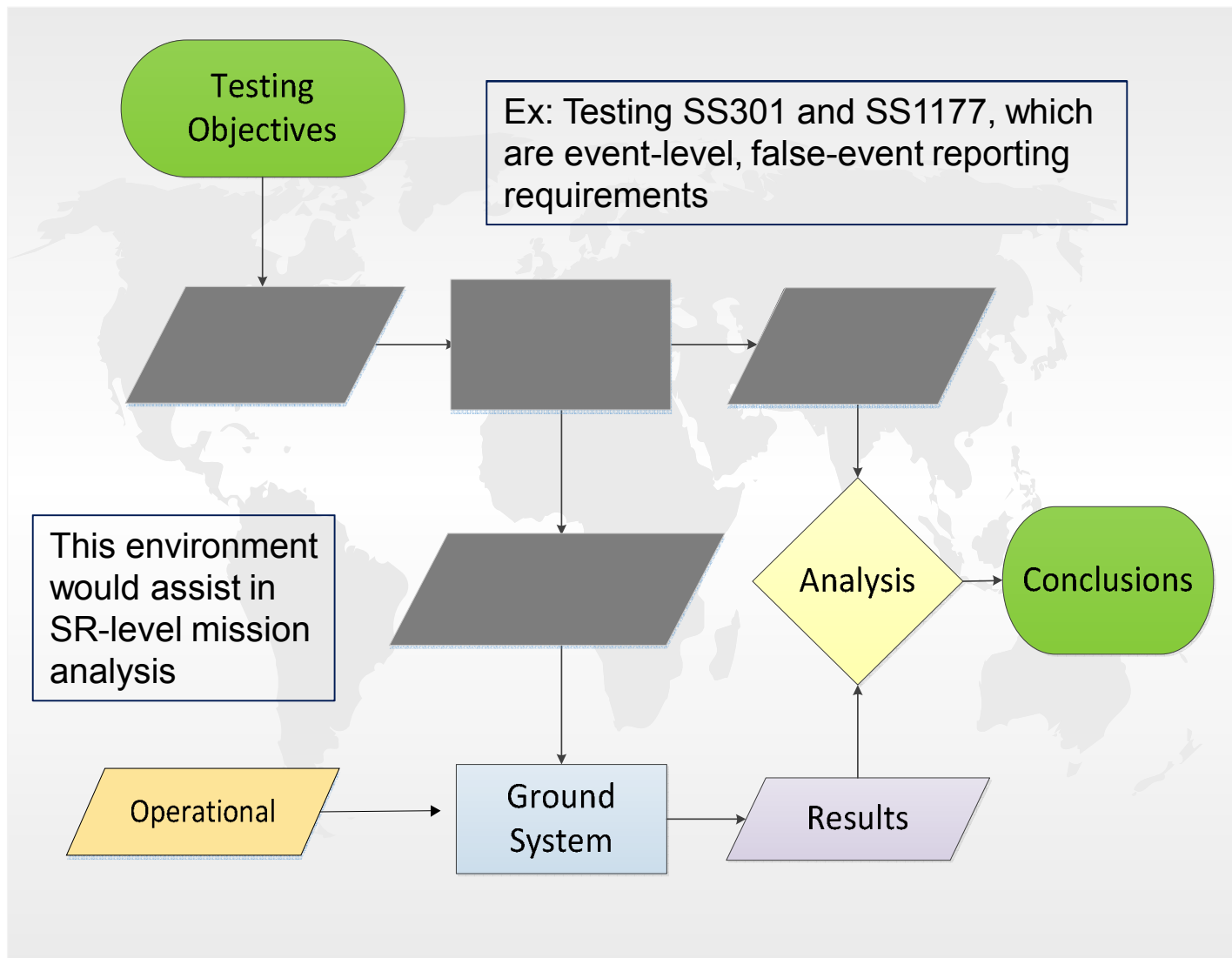
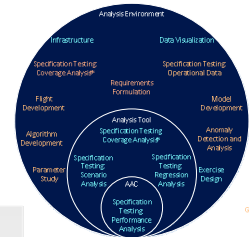
Key:		Essential Objectives	Goals	System / Application					
Function			AAC		Analysis Tool		Analysis Environment		
Category	Sub-Category	Description	Simulation	Operational	Simulation	Operational	Simulation	Operational	
Infrastructure	Analysis Access	Improve accessibility to analyses	--	--	--	--	X	X	
Infrastructure	Analysis Storage	Improve analysis storage and associate with data	--	--	--	--	X	X	
Infrastructure	Data Access	Improve data access	--	--	--	--	X	X	
Infrastructure	Data Storage	Improve data storage	--	--	--	--	X	Storage	
Infrastructure	Metadata Access	Improve access to metadata for testing/studies	--	--	--	--	X	X	
Infrastructure	Adaptation	Adapt to surrounding technological life extensions	--	--	--	--	X	X	
Infrastructure	Update Interface	Migrate from IDL, rigorous software development	--	--	--	--	X	X	
Specification Testing	Coverage Analysis	Analyze system requirements coverage	--	--	X	--	X	X	
Specification Testing	Performance Analysis	Analyze system performance against system requirements	X	--	X	--	X	X	
Data Visualization	Sensor/Algorithm Visualization	Plotting capabilities to examine sensor/algorithm responses (full life cycle visualization, etc.)	--	--	--	--	X	X	
Data Visualization	Truth Visualization	Ability to trace an event through its full life cycle visually	--	--	--	--	X	X	
Algorithm Development	Algorithm Development Analysis	Aid in formulation of new algorithm changes via "before and after" analyses	--	--	--	--	X	X	
Algorithm Development	Parameter Space Formulation	Aid in parameter space formulation for new algorithms	--	--	--	--	X	X	
Algorithm Development	Verification and Validation	Aid in Verification & Validation efforts for algorithm development	--	--	--	--	X	X	
Algorithm Development	Harnessed Mission Algorithms	Utilize extracted algorithm implementations from Ground System and utilize Algorithm SME analysis tools to operate on the data	--	--	--	--	X	X	
Anomaly Detection/Analysis	Mission Event Reports	Examine trends/regression in Event Report characteristics (Updates, Identification, Locations, Etc.)	--	--	--	--	X	X	
Anomaly Detection/Analysis	Mission Sensor Reports	Examine trends/regression in Sensor Report characteristics by sensor type & blocks (Identifications, Time of Arrival Calculations, Etc.)	--	--	--	--	X	X	
Anomaly Detection/Analysis	Sensor SOH	Employ automated statistical control theory to monitor State Of Health metrics, commanding, and performance	--	--	--	--	X	X	
Exercise Design	Design of High-Fidelity Exercise	Aid in design of high-fidelity exercises	--	--	--	--	X	X	
Flight Development	Flight Development Analysis	Aid in formulation of new sensors or sensor commanding via "current vs proposed" analyses	--	--	--	--	X	X	
Flight Development	Verification and Validation	Aid in Verification & Validation efforts for flight development	--	--	--	--	X	X	
Model Development	Model Development Analysis	Aid in formulation of new model changes via "before and after" analyses	--	--	--	--	X	X	
Model Development	Verification and Validation	Aid in Verification & Validation efforts for model development	--	--	--	--	X	X	
Parameter Study	Design of Experiment	Provide utilities for designing experiments	--	--	--	--	X	X	
Parameter Study	Mission Performance	Examine/formulate parameter space for mission studies	--	--	--	--	X	X	
Parameter Study	Sensor Performance	Examine/formulate parameter space for sensor studies	--	--	--	--	X	X	
Requirements Formulation	Parameter Space Formulation	Aid in parameter space formulation for new requirements	--	--	--	--	X	X	
Requirements Formulation	Requirements Traceability	Achieve requirements formulation throughout the system requirements flow (show at System Spec level, Ground Segment, ...)	--	--	--	--	X	X	

Performance Analysis Environment

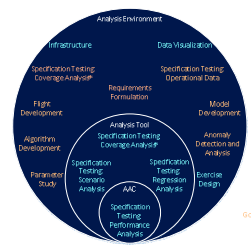


Function			System/Application					
			AAC		Analysis Tool		UAE	
Category	Sub-Category	Description	Simulation	Operational	Simulation	Operational	Simulation	Operational
Specification Testing	Performance Analysis	Analyze system performance against system requirements	X	--	X	--	X	X

Performance Analysis Environment



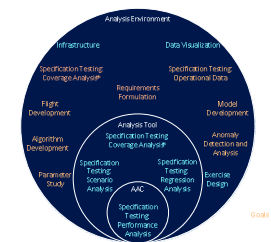
Methodologies



- Determine Scope
 - Provide estimates to accompany scope options (via proposal and potential follow-up)
 - Program Office/Systems Engineering decide on scope option
- Prototype
 - Enlist Otero-like team to aid in prototyping to test the concept
 - Work with teams to formulate user stories
- Develop Software
 - If proven, stand up a software team, including an architect, to develop the Analysis Environment software
 - Program Office, System Engineering, mission analysts, and others providing requirements
 - Teams must work closely with numerous other efforts to ensure design and interfacing are optimized

Imperative that effort funded at a level that promotes quality (Design Review, Documentation, Etc.)

Options



- Option 1: Minimum Requirements

- Essential Objectives

- Infrastructure

- Essential improvements to analysis system infrastructure

- Necessary Improvements

- Address known deficiencies

- Software rigor

- Option 2: Ideal Option

- Essential Objectives

- Goals

- *All* Proposed Enhancements to Analysis System Capabilities

- Option 3: Middle Ground

- Essential Objectives

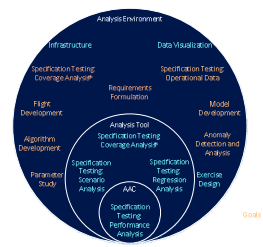
- Some Goals

- *Some* Proposed Enhancements to Analysis System Capabilities

Key:	Essential Objectives	Goals
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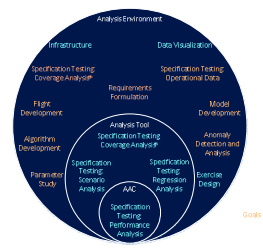
Category	Item	Essential Objectives	Goals
Essential Objectives	Infrastructure	Y	Y
	Algorithm Development	Y	Y
	Specification Testing Coverage Analysis	Y	Y
	Requirements Formulation	Y	Y
	Specification Testing	Y	Y
	Scenario Analysis	Y	Y
	Regression Analysis	Y	Y
	Specification Testing Performance Analysis	Y	Y
	Analysis Tools	Y	Y
	Parameter Study	Y	Y
Goals	Model Development	Y	Y
	Anomaly Detection and Analysis	Y	Y
	Error Design	Y	Y
	Operational Data	Y	Y
	Data Visualization	Y	Y
	Operational Data	Y	Y
	Operational Data	Y	Y
	Operational Data	Y	Y
	Operational Data	Y	Y
	Operational Data	Y	Y

Phased Approach



- If necessary, this endeavor could be completed in phases
 - Phase 1
 - Incorporate all infrastructure updates to adapt to surrounding Technological Life Extension Efforts
 - Phase 2
 - Complete all necessary improvements
 - Phase 3, 4, 5, etc.
 - Provide enhancements to capabilities depending on funding available
 - Recruit various teams to fund enhancements that would directly impact their own work

Cost & Timing



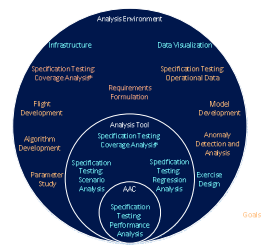
■ Cost

- Currently formulating estimates for the various scopes of this endeavor
 - Utilizing various software estimation methods
 - If phased approach is accepted, calculate estimates for different phases
- Pay up-front
 - Gain efficiency, transparency, and cohesion for the future

■ Timing

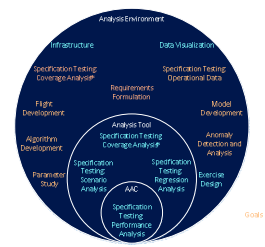
- Individual timing estimates will be calculated for different scopes (potentially calculated for individual phases)

Value



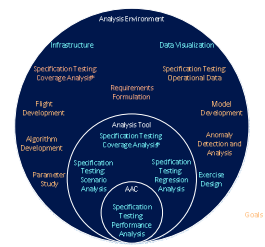
- Minimum requirements value:
 - Analysis Software **does not become obsolete**
 - Mission Analysts can **continue to do their jobs**
- Enhancements value:
 - Improved **consistency** of analyses
 - Increased productivity leads to **additional analyses** in the same amount of time or less
 - More **powerful, united system**

Conclusion



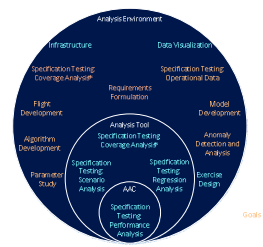
- System Analysis Environment will provide users with an **updated, efficient and comprehensive** analysis environment
- **Infrastructure updates** and **necessary improvements** *must* occur to continue to be a functioning tool. Any scope chosen must apply **software development rigor** (and would need to be **funded accordingly**)
- **Enhancements** to the capabilities would improve **cohesion** among the department, **consistency** of analyses, and **productivity** of employees
- Better analyses would enable a more **robust system**, facilitating the system to effectively **resolve emerging national security challenges**

Path Forward



- Mission Analysts
 - Examine similar efforts (Dynamic Analysis Environment: DAE)
 - Continue to formulate estimates for the various scopes
 - Provide proposal with cost and timing estimates
- Program Office
 - Decide on scope that is agreeable to be pursued at this time given pending cost and timing estimates
 - Determine if available funds may be used to prototype this effort
 - Determine if Phased Approach is preferred
- Mission Analysts/Program Office
 - Continue discussion on path forward

Take Away



- Understanding this complex system of systems
- Importance of efficiency
- Presenting a proposal
- Writing a proposal
- Difficulty getting manpower
- Creating user stories/use cases
- Documenting algorithms written in IDL

Continuing to pursue this refresh effort as a telecommuter