



Tactical Assured GPS Regional (TAGR) Analysis of Alternatives



Agenda

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- **Tactical Assured GPS Regional (TAGR) Overview**
- **Study Progress**
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- **Study Plan Overview**
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 - **Constraints and Assumptions**
 - **Alternatives**
 - **Study Methodology**



Purpose

- Present the planned approach for the TAGR Analysis of Alternatives.



Background

- Positioning, Navigation, and Timing (PNT) Joint Capability Document (JCD) – September 2006
- PNT FSA - March 2008
- PNT Assurance ICD - April 2010
- HQDA G3/5/7 Request for MDD - May 2010
- DASM Review - July 2011
- TRADOC ARCIC Study Directive - September 2011
- TAGR ADM from AAE - September 2011



TAGR Overview

What is Tactical Assured GPS Regional (TAGR)?

TAGR is a system concept that provides PNT Assurance through the use of advanced anti-jam, self-locating, and timing technologies to provide GPS like service in electronically or physically challenged environments.

The Problem

Army forces, brigade and below, lack the ability to obtain PNT information from Global Positioning System signals or other radio frequency (RF) reliant PNT information sources while operating in conditions that impede or deny access to RF signals, including operating in dense vegetation, built-up urban and mountainous terrain, subterranean and underwater operations, and in the presence of electromagnetic interference or enemy jamming and spoofing of the GPS or other RF reliant PNT information.

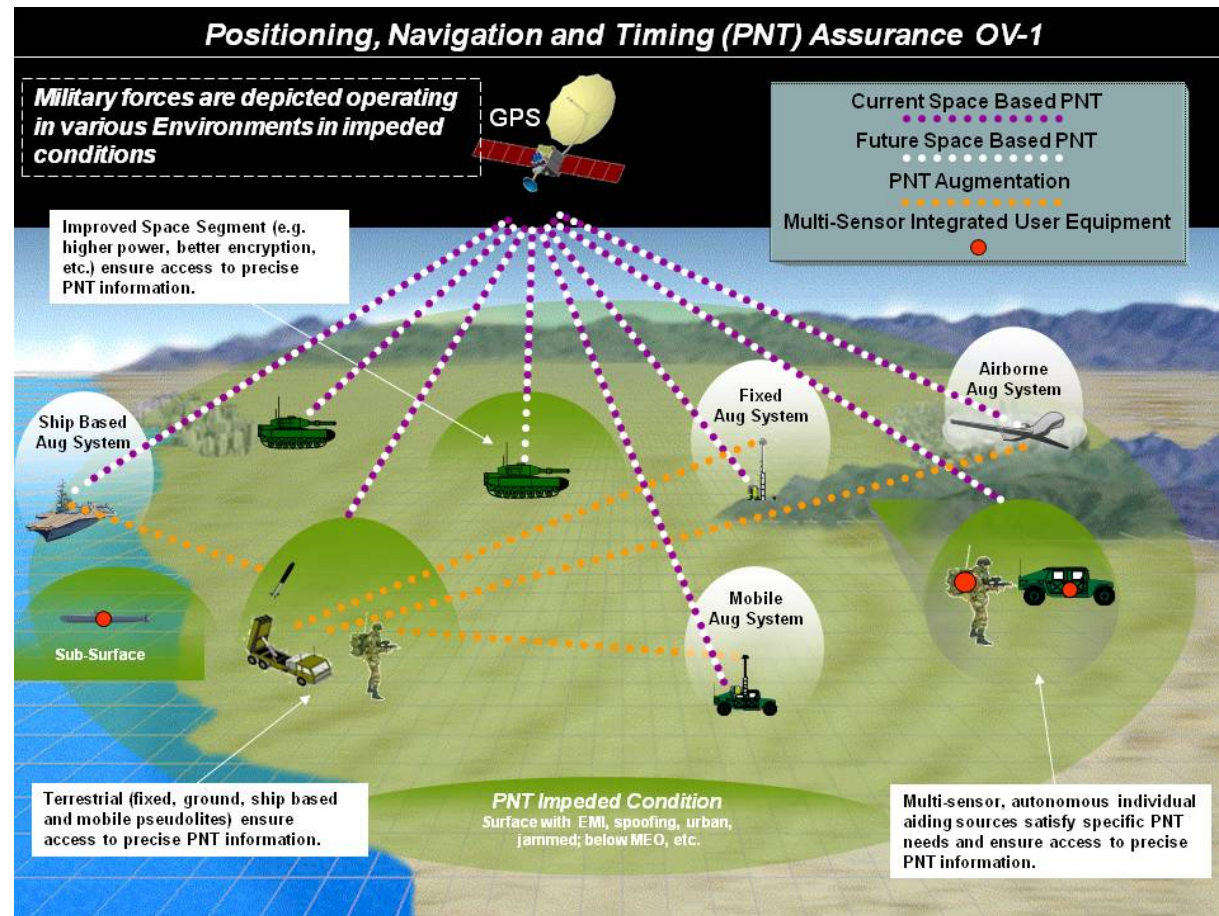
Material Solution

The Army Acquisition Executive, ASA(ALT), initiated the AoA for TAGR on 20 September 2011.

Benefits to Warfighter

Provides access to PNT information in impeded (electronically or physically constrained) environments.

- Continued operation of PNT dependent systems such as Blue Force Tracker, precision guided munitions and precision fires platforms.





Operational Gaps

PNT Assurance ICD Gaps

Capability Gap 1: Inability to access PNT information in impeded conditions.

•Natural terrain and urban impediments to PNT availability, as well as intentional and unintentional man-made interference preclude assured access to PNT information.

Capability Gap 2: Inability to determine validity and accuracy of PNT information.

•Users require notification of degraded or misleading information within a user defined time standard.

Army Specific Gaps

Mission Command

- degraded network timing
- unreliable or unavailable input to COP

Movement and Maneuver

- degraded network timing
- degraded self location
- degraded navigation

Protection

- degraded self location
- degraded network timing

Fires

- degraded self location (platform and munitions)
- degraded navigation
- network timing
- unreliable or unavailable input to COP

Intelligence

- degraded network timing
- unreliable or unavailable targeting data

Sustainment

- degraded network timing
- unreliable or unavailable input to COP

Potential Impacts

Network degradation-unavailability

Unreliable or unavailable PLI

Degraded COP

Decreased obstacle avoidance

Increased movement time

Delayed warnings

Delayed countermeasures

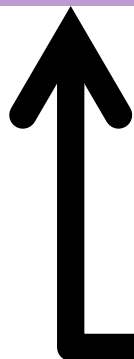
Degraded Accuracy (CEP)

Missed Opportunities

Increased TLE

Missed Opportunities

Reduced Timeliness





Study Progress Review

The PNT Assurance study team has worked together to conduct the foundational activities for a successful Milestone (MS) A AoA.

- Identified baseline operational attributes to describe the required capability.
- Identified candidate technologies and initial employment concepts associated with alternatives in study directive.
- Selected scenario (TRADOC Approved – Multiple Level Scenario-Module II).
- Developed vignettes with operational conditions that are designed to distinguish the alternatives' ability to mitigate gaps.
- Selected the analytic methods for operational benefit, gap mitigation, performance, cost, technical risk, schedule risk analysis.
- Developed a draft study plan.



Study Purpose and Deliverables

This AoA is for a Milestone A decision to provide a PNT assurance capability to the Army.

- **Purpose:**
 - Support an ACAT III MS A program decision in 1QFY13.
 - Inform requirements development, including a draft Capability Development Document (CDD).
 - Inform the technology development strategy.
- **AoA Deliverables:**
 - Report that answer study directive issues



Study Issues

Objective

1. To what extent does each alternative mitigate the PNT assurance capability gaps?
2. What key attributes are required to satisfy the identified capability gaps?
3. What are the technologies associated with these attributes?
4. What are the cost drivers associated with these technologies?
5. What are the risks associated with each of these technologies?
6. What is the affordable cost target for TAGR?
7. What are the opportunities for cost sharing (joint program) or cost avoidance (other capability mitigates the gap)?



Study Scope

- The AoA will consider all technologies determined to be feasible and affordable in the 2015-2025 timeframe and their ability to mitigate the specific capability gaps identified in the PNT Assurance ICD.
- The AoA will include a thorough review of the literature and all current and programmed PNT assurance capabilities.
- The study will characterize the degree of threat, specifying the size of the geographic area affected, and assess to what degree alternate restoration for PNT must be provided.



Constraints and Assumptions (1 of 2)

- **Constraints:**

- Final report due 30 days prior to 1st Quarter FY 13 (OCT-DEC 2012) Milestone A*.

- **Assumptions:**

- Time frame for AoA is 2015 through 2025.
- Time frame will be broken down into three periods for assessment, 2015, 2020, 2025 the National Space Intelligence Center System Threat Assessment Report will guide the level of threat for the 3 time periods.
- Analysis will focus on three types of BCTs (HBCT, SBCT, IBCT)

* Current plan from PEO IEW&S, PD PNT is MS A 1st QTR FY13



Constraints and Assumptions (2 of 2)

•Assumptions:

- Blue Force Electronic Attack (BFEA) will be capable of denying access to unprotected GPS and Global Navigation Satellite Systems (GNSS) in the 2020-2025 timeframe.
- RF bandwidth for network aiding of PNT will be limited to 5% of total available bandwidth.
- The average procurement unit cost (APUC) will be sufficient to conduct cost target, cost risk and trades analysis.
- LCCE will cover a 15 year period.

* Current plan from PEO IEW&S, PD PNT is MS A 1st QTR FY13

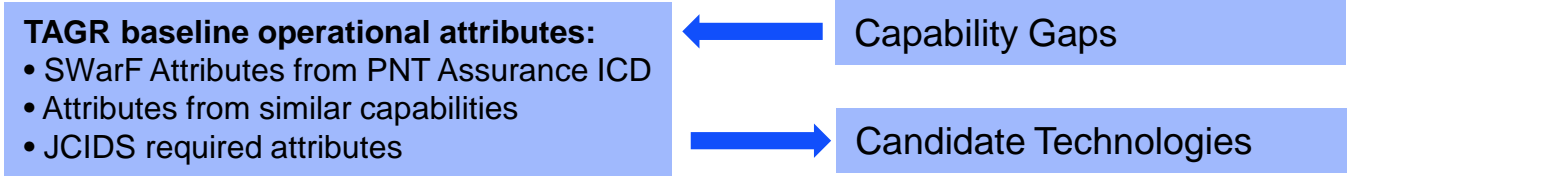


Alternatives

1. Base Case: Continued use of GPS, to include programmed improvements for higher satellite transmission power, enhanced receiver electronics to mitigate electronic warfare challenges, and current augmentation such as EPLRS and inertial navigation.
2. Pseudolites for PNT assurance that include terrestrial or aerial radio frequency transmitters or beacons that possess higher power GPS or GPS-like signal retransmission capabilities received by current GPS systems.
3. RF based systems such as e-LORAN-like systems, cellular ranging, and utilization of other RF emitters.
4. Joint PNT programs including Image-aided INS, CSAC, and MEMS-IMU.
5. Other sensors and GPS augmentation technologies or other PNT assurance technologies identified as having a reasonable gap mitigating capability such as odometer-coupled systems and dead-reckoning systems.



TAGR Operational Attributes

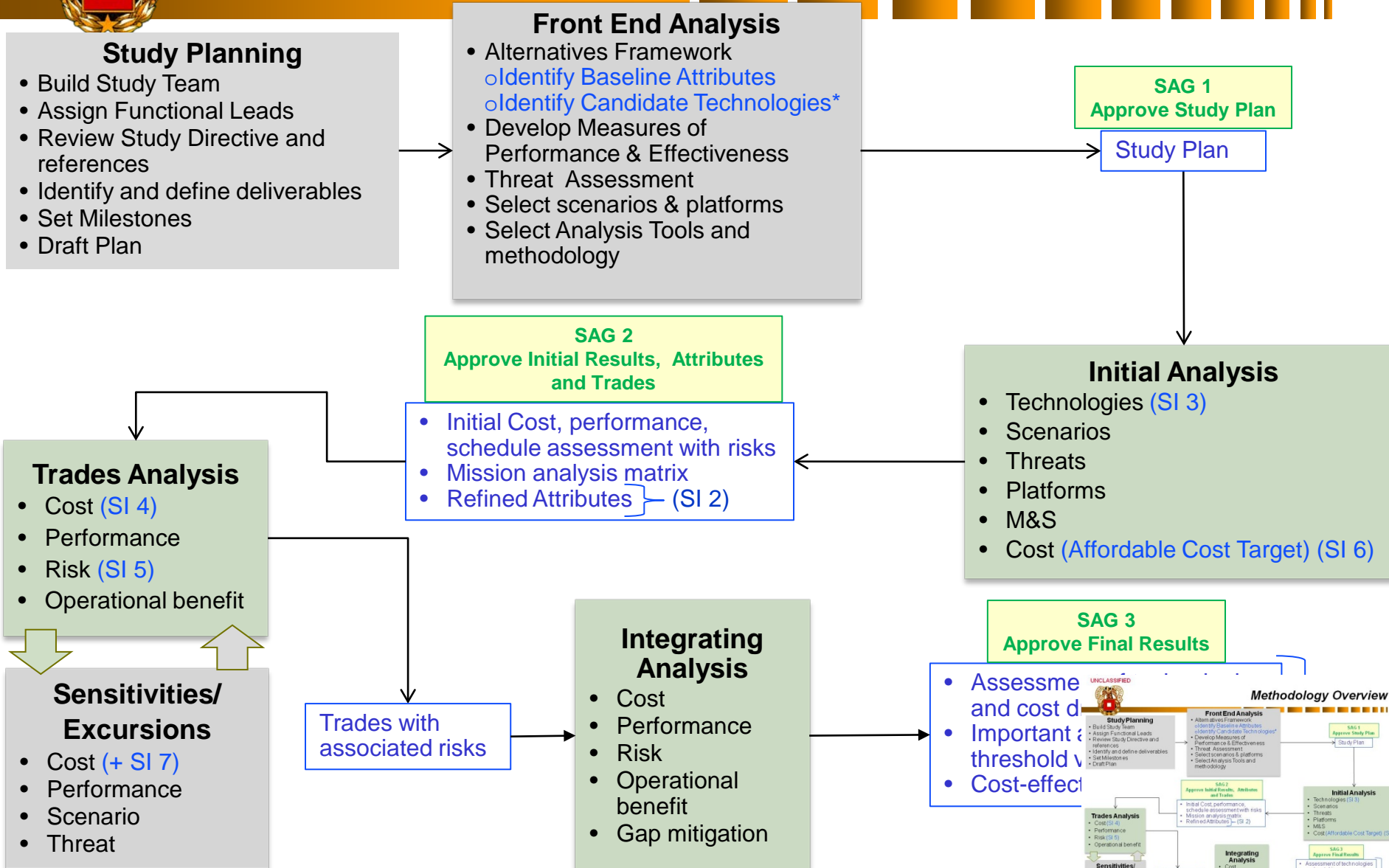


CATEGORY	OPERATIONAL ATTRIBUTES		
PNT ASSURANCE	<ul style="list-style-type: none"> • Accessible (% time) • Scalable (# supported (soldier, system, platform), km²) • Responsive (sec,min, hours) • Accurate (% change ± in CEP) 	<ul style="list-style-type: none"> • Robust (% usable PNT received) <ul style="list-style-type: none"> ○ Jamming Resistance (J/S) ○ Availability (% received) 	<ul style="list-style-type: none"> • Mission duration (min, hour, day) • Expeditionary (air lift, man portable) • Force structure (# ±)
PNT INTEGRITY	<ul style="list-style-type: none"> • Authentication (%) <ul style="list-style-type: none"> ○ Spoofing Identified ○ Invalid Signals Identified 	<ul style="list-style-type: none"> • Reliable (%) 	
NETWORKED	<ul style="list-style-type: none"> • Users (#) • Over what? (waveform, transport) • Message types (list) 	<ul style="list-style-type: none"> • TAGR/ systems networked with (list) • Level of networked system control (who can control) 	
FORM FACTOR	<ul style="list-style-type: none"> • Platform (Soldier, vehicle, UAS) • Size (cube m) • Weight (kg) • Run time/ battery time (min/hour/day) 	<ul style="list-style-type: none"> • Power draw (W) • Set up time (min) • Tear down time (min) • Operational availability/ RAM 	<ul style="list-style-type: none"> • Sustainable <ul style="list-style-type: none"> ○ Availability (% Material, % Operational) ○ Reliability (%) ○ Ownership Cost

Attributes will be further refined to achieve measurable results across all as part of initial analysis.



Methodology Overview



Study Planning

- Build Study Team
- Assign Functional Leads
- Review Study Directive and references
- Identify and define deliverables
- Set Milestones
- Draft Plan

Front End Analysis

- Alternatives Framework
 - Identify Baseline Attributes
 - Identify Candidate Technologies*
- Develop Measures of Performance & Effectiveness
- Threat Assessment
- Select scenarios & platforms
- Select Analysis Tools and methodology

SAG 1
Approve Study Plan

Study Plan

Initial Analysis

- Technologies (SI 3)
- Scenarios
- Threats
- Platforms
- M&S
- Cost (Affordable Cost Target) (SI 6)

SAG 2
Approve Initial Results, Attributes and Trades

- Initial Cost, performance, schedule assessment with risks
- Mission analysis matrix
- Refined Attributes (SI 2)

Trades Analysis

- Cost (SI 4)
- Performance
- Risk (SI 5)
- Operational benefit

Integrating Analysis

- Cost
- Performance
- Risk
- Operational benefit
- Gap mitigation

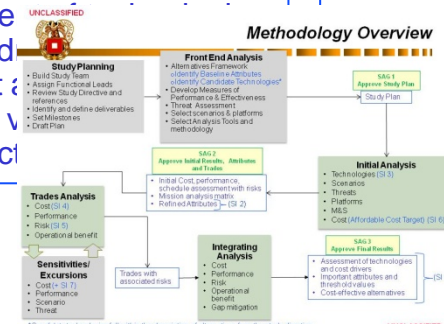
Trades with associated risks

Sensitivities/Excursions

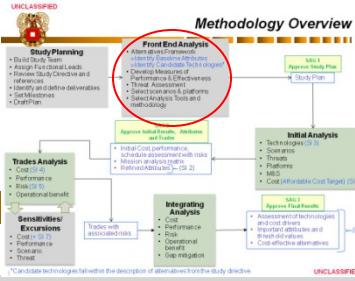
- Cost (+ SI 7)
- Performance
- Scenario
- Threat

SAG 3
Approve Final Results

- Assessment and cost d...
- Important threshold v...
- Cost-effecti...



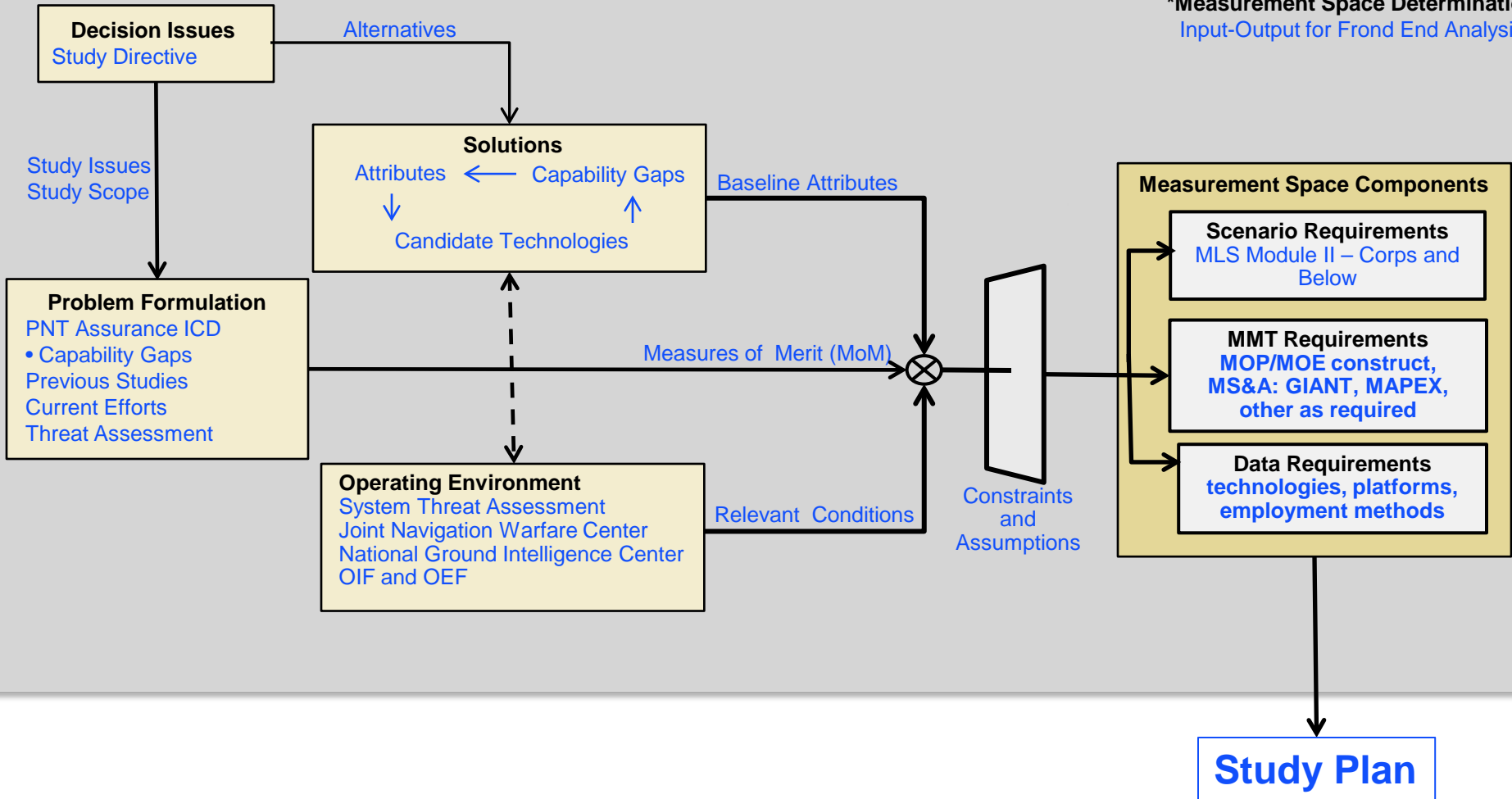
*Candidate technologies fall within the description of alternatives from the study directive.



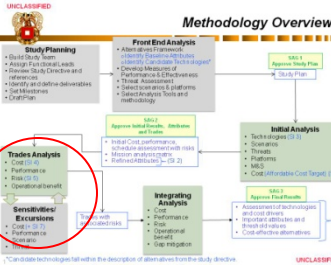
Methodology Details

Front End Analysis

*Measurement Space Determination
Input-Output for Front End Analysis



* TRADOC Analysis Center brief dated



Methodology Details

Trades Analysis and Sensitivities / Excursions

- Residual gap.
- Unmet op'n'l demand.
- Sub-threshold system performance.
- System cost over target.
- System schedule beyond goal.
- Moderate-high technical risk.

Unacceptable trades and residual risk.

Trades Analysis

Integrate risk assessments and develop trade space.

GIANT / SME FEB-MAR
MAR-MAY

- Proposed system-level trades.
- Proposed mix trades.

"Traded" system alternatives.

Assess cost risk. ↔ Assess schedule/technical risk.

↕

Assess performance.

GIANT / Risk models MAR-MAY

- Change to system performance.
- Change to cost, schedule, and technical risk.

Assess TAGR gap mitigation.

GIANT / SME MAR-MAY

- Change to gap mitigation.

Assess TAGR mixes.

GIANT / SME MAR-MAY

- Change to demand satisfaction.

- "Traded" mix alternatives.
- Updated performance data.

Emerging Results

Acceptable trades and residual risk.

Independent results

Sensitivities / Excursions

- Cost anomalies
- Performance anomalies
- Scenario anomalies
- Threat anomalies

Assess Cost Sensitivity

Analogy/Parametric FEB-MAR
MAR-MAY

Assess Performance Sensitivity

GIANT / SME FEB-MAR
MAR-MAY

Assess Scenario Sensitivity

SME FEB-MAR
MAR-MAY

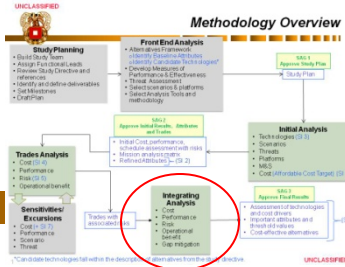
Assess Threat Sensitivity

SME FEB-MAR
MAR-MAY

Excursion

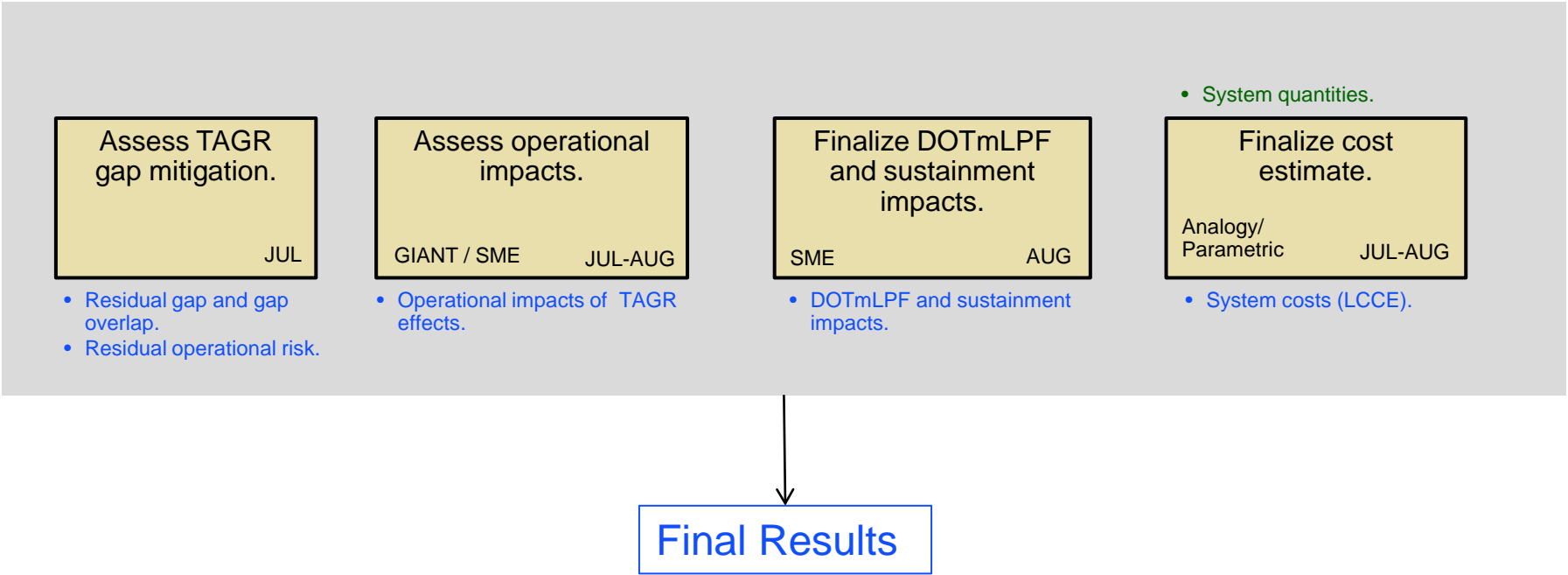
GIANT / SME/Analogy/Parametric

Proposed Parameter Changes



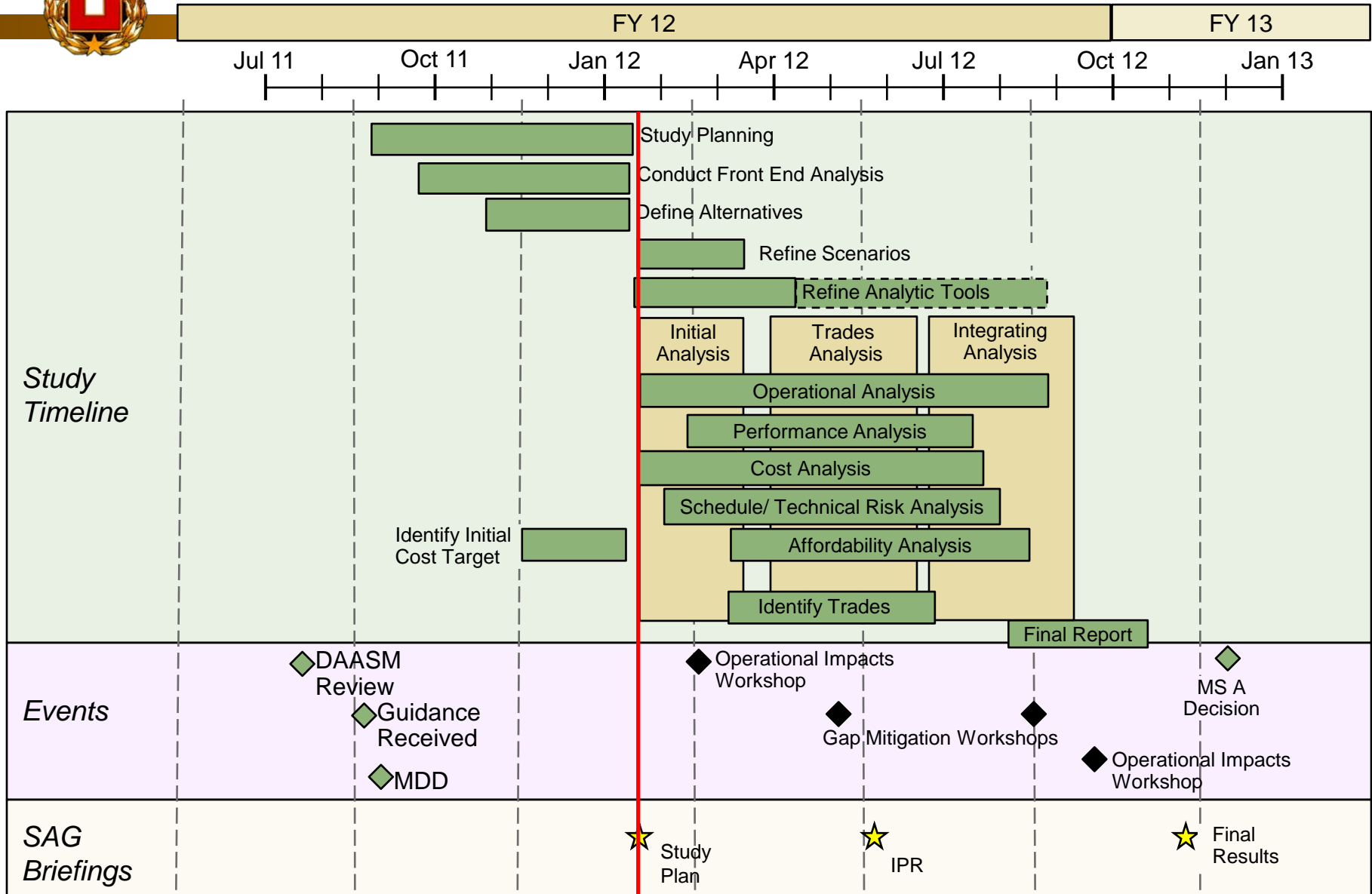
Methodology Details Integration

Emerging results from TAGR AoA.





Timeline





Backup

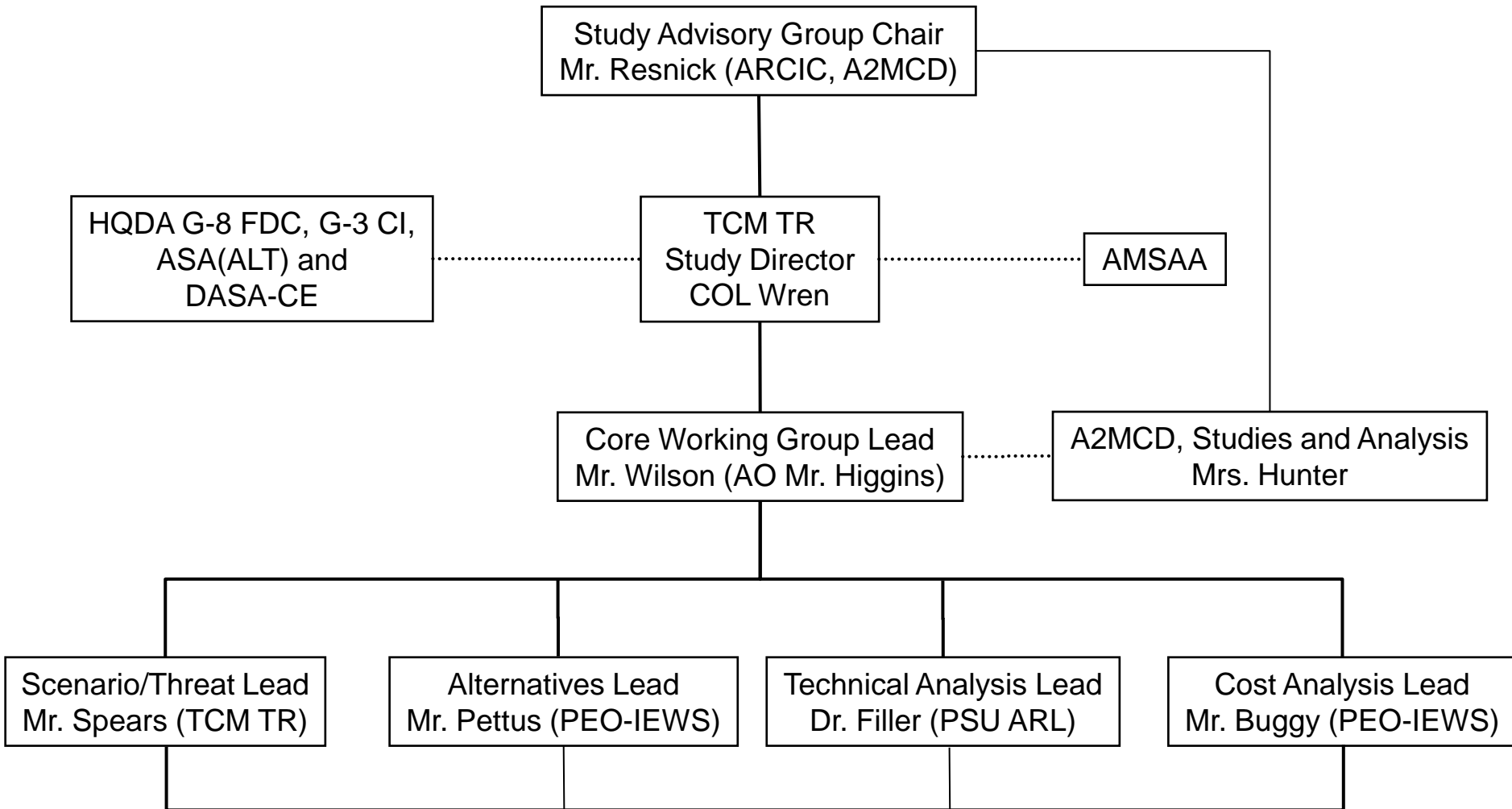


Initial Assessment of Candidate Alternatives

- This AoA will consider the five alternatives as stated in the AoA study guidance.
- The set of technology alternatives beyond current GPS capability will be assessed using their expected performance and deployment in the 2015-2020 and 2020-2025 time frames.
- The methodology used in selecting alternatives to be used in this AoA focused on selecting alternatives that best address the gaps identified in the PNT Assurance ICD.
- The criteria used in the alternatives selection were:
 - The alternative must have the expectation to be effective in addressing the gap(s) in a significant way.
 - The alternative must be available in the targeted time frames with minimal risk given the alternatives development have either started or are underway today.
 - The alternative must have a sound technical foundation and/or be well described to enable evaluation through either an analytical means or in sufficient detail to be included in a constructive simulation.
 - The alternative must, in its deployable form, have a reasonable size, weight, power consumption, cost, and integration approach either into the Army force structure or onto specific platforms.



Study Team Organization





Scenario

TRADOC developed Multi-Level Scenario Module 2 (MLS-2.0) include a set of operations where the status quo is not sufficient. Platforms will be players in a scenario with associated technologies. The scenarios must In addition, the chosen scenarios must differentiate among the various alternatives, including conditions where several technologies, in combination, will satisfy the requirements. It is expected that some of the scenarios will not be satisfied by any of the technology alternatives. The AoA will use the. This scenario will be used to establish a performance baseline for various representative US military weapons, platforms, and weapon platforms in both a benign and a hostile PNT environment. Vignettes extracted from this scenario are designed to capture the full range of military operations. The following are short summaries of the vignettes.



Vignette 1

A Heavy Brigade Combat Team (HBCT) Battalion secures a hostile urban area. The companies are required to traverse narrow streets with tall buildings on either side. Improvised explosive devices are prevalent. Elements of the battalion clear buildings floor by floor with some buildings having basements. The battalion receives fire support from organic mortars (w/PGK) as well as light artillery (105mm PGK). The enemy has the ability to use Global Navigation Satellite Systems (GNSS)-aided systems (mortars, Unmanned Aircraft Systems [UASs], light artillery) against friendly forces. Blue Force Electronic Attack (BFEA) may be used (time period dependent).



Vignette 2

An Infantry Brigade Combat Team (IBCT) Battalion conducts a raid on an isolated enemy weapons cache. The weapons cache is protected by well emplaced Air Defense Artillery (ADA) and Man Portable Air Defense Systems (MANPADS), requiring the use of ground forces. In addition, it is suspected that man-portable GPS jammers are in the vicinity. Two companies from the battalion maneuver at night to within 2 km of the objective and disperse into platoons to execute the raid. Visual contact between the platoons is negligible due to darkness and obstructions. Two adjacent squads are engaged by enemy forces while in route to objective. The squads utilize direct and indirect fires, including company mortars to neutralize the enemy and destroy the weapons cache. Upon successful completion of the mission, the company reassembles and moves to a designated rally point for aerial extraction.



Vignette 3

An Airborne Brigade Combat Team (ABCT) conducts operations to seize and secure an enemy airfield to establish a forward operating base and air re-fueling point in support of an amphibious landing. The airfield is well defended with conventional (light infantry) as well as electronic warfare (communications and GPS) measures. In addition to organic assets, the ABCT will be supported by naval gun for preparatory fires and close air support once ADA emplacements have been suppressed or destroyed.



Navigation Warfare (NAVWAR)

Navigation Warfare (NAVWAR) - Deliberate military operations to gain and maintain a positioning, navigation, and timing information advantage. Desired effects are generated through the coordinated employment of components within information operations, space operations, and cyberspace operations, including electronic warfare, space control, space force enhancement, and computer network operations.



- Who uses PNT? (representative examples)
 - Soldiers (DAGR, PLGR, Nett Warrior, etc.)
 - Battle Command Systems (Communications, FBCB2, BFT, MTS, etc.)
 - Precision Guided Munitions (GMLRS, Excalibur)
 - Protection (Radar, ADA)
- What's the impact if the PNT information is not available or misleading?
 - Soldiers (fratricide, enter mine fields, follow wrong route)
 - Battle Command Systems (fratricide, loss of SA)
 - Precision Guided Munitions (fratricide, multiple strike, collateral damage)
- What is the primary provider for DoD of PNT?
 - Global Positioning System (GPS)



Alternatives Framework

Identify attributes that mitigate defined capability gaps.



Identify technologies that possess these attributes.

Assess alternatives comprised of these technologies.

Technology Components

- New Signals in Space
- Antenna Tech.
- Adv. Algorithms
- Receivers
- Transmitters
- Platforms
- Controllers
- Anti-Jam
- Interfaces
- BFEA
- BFEA Filters
- Tachometer/Wheel Encoders
- Atomic Oscillators
- MEMs Gyros
- MEMS Accel
- Barometric Pressure Sensors
- Azimuth Sensors

System/Sub-Systems

- P (Y)-Code Receiver
- FRPA
- CRPA
- Pseudolite Transmitters
- Network Communications
- M-Code Receiver
- Altimeter
- Pedometry
- Odometry
- High Accuracy Low Power Clocks
- Digital Compass
- Small IMU
- Small 4 Element Antenna Array
- Adv. Antenna Elec.

Alternatives

- 1 Base Case
- 2 Pseudolites
- 3 RF Based
- 4 Multi-Sensor
- MGUE
- 5 A/J Antenna

Multiple linkages across candidate technologies and alternatives.



PNT Assurance and TAGR

What is Positioning, Navigation and Timing?

- PNT is used to describe three distinct capabilities; positioning, navigation and timing. Space based PNT (GPS) is an essential tactical resource. For example; PNT enables commanders to visualize the operational area through location determination of blue and red forces and the ability to employ precision guided munitions. PNT is a tier three Joint Capability Area under tier two Enterprise Services and tier one Net-centric.

What is PNT Assurance?

- The methods and capabilities employed to assure warfighter access to PNT information where and when required.

What is TAGR?

- Tactical Assured GPS Regional (TAGR) is a system concept that provides PNT Assurance through the use of advanced anti-jam, self-locating, and timing technologies to provide GPS like service in electronically or physically challenged environments.

PNT Assurance ICD

Capability Gaps Attributes



Capability Gap Description					
Priority	Tier 1 & Tier 2 JCAs	SWarF Attributes	Description	Metrics	Minimum Value
High	Tier 1 Net-Centric Tier 2 Enterprise Services	Accessible, Scalable, Responsive, Robust	Inability to access PNT information in impeded conditions.	Percentage of time the user has access to PNT that is accurate enough to support the mission.	98 Percent
				Percentage of time that PNT user effectiveness is not degraded by enemy deception efforts measured in the presence of deception efforts.	90 Percent
				Percentage of the time when PNT data can be provided within a mission defined time requirement.	99.8 Percent
High	Tier 1 Net-Centric Tier 2 Enterprise Services	Survivable, Timely, Reliable, Accurate	Inability to determine validity and accuracy of PNT information.	Percentage of mission time that PNT user equipment detects and reports degraded PNT accuracy, measured when PNT accuracy is degraded by more than the mission specific safety requirement.	99 Percent

Positioning, Navigation and Timing (PNT) Assurance OV-1

Military forces are depicted operating in various Environments in impeded conditions



Current Space Based PNT
Future Space Based PNT
PNT Augmentation
Multi-Sensor Integrated User Equipment

Improved Space Segment (e.g. higher power, better encryption, etc.) ensure access to precise PNT information.

Ship Based Aug System



Sub-Surface



Terrestrial (fixed, ground, ship based and mobile pseudolites) ensure access to precise PNT information.

PNT Impeded Condition
Surface with EMI, spoofing, urban, jammed; below MEO, etc.

Multi-sensor, autonomous individual aiding sources satisfy specific PNT needs and ensure access to precise PNT information.

