# ARMY SCIENCE BOARD

## FY2008 SUMMER STUDY

## FINAL REPORT

DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
(ACQUISITION, LOGISTICS AND TECHNOLOGY)
WASHINGTON, D.C. 20310-0103

# "Platforms for Persistent Communications, Surveillance and Reconnaissance"

## September 2008

## DISCLAIMER

**This report is the product of the Army Science Board (ASB). The ASB is an independent, objective advisory group to the Secretary of the Army (SA) and the Chief of Staff, Army (CSA). Statements, opinions, recommendations and/or conclusions contained in this report are those of the 2008 Summer Study Panel on "Platforms for Persistent Communications, Surveillance and Reconnaissance" and do not necessarily reflect the official position of the United States Army or the Department of Defense (DoD).**

## CONFLICT OF INTEREST

**Conflicts of interest did not become apparent as a result of the Panel's recommendations.**

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-- For a complete listing of all participants see Appendix B

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**13. ABSTRACT (Maximum 200 words)**

Studies of military operations indicate a need for improvements in persistent communications, reconnaissance and surveillance (CSR). The Army Science Board investigated capabilities of platforms deployed in space, near space and lower altitudes and assessed tradeoffs among benefits, weaknesses, costs and logistics burdens associated with platform types.

The study used a model to assess platform types versus relevant characteristics. Key findings include: persistence is not well defined; there are gaps in coverage; communications relay capabilities are inadequate; use of commercial space platforms for communications relay is very costly; large aircraft (e.g., KC-135) could be utilized for communications relay; proponency for CSR platforms is distributed and many solutions are ad hoc; no integrated mission Analysis of Alternatives (AoA) was found; satellites are not sufficiently responsive to lower echelon commanders; unmanned platforms are increasingly effective and accepted; and Lighter than Air (LTA) platforms have great potential.

Major recommendations include: assign proponency for LTA to the Aviation Center; retain proponency for High Altitude LTA platforms at SMDC; accelerate Medium Altitude LTA (untethered) prototypes for joint CSR experiments; invest to mature High Altitude LTA airship CSR platforms; form LTA Integrated Product Team (IPT) of technologists, material developers, and combat developers; conduct an integrated Analysis of Alternatives for CSR platforms mixes.

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**Platforms for Persistent Communications, Surveillance and Reconnaissance**

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# Platforms for Persistent Communications, Surveillance and Reconnaissance

**July 24, 2008**

*Study Co-Chairs:*
*LTG(Ret) William Campbell, Mr. Chuck Vehlow*
*Dr. Mike Wartell*

# Persistent CSR Study Membership

**CO-CHAIRS**

**LTG(Ret) William Campbell** **Mr. Chuck Vehlow** **Dr. Mike Wartell**

**STUDY TEAMS**

Senior Government Advisor –
Mr. Tom Pagán

Study Manager
Ms. Anorme Anim – ASB

**Communications (Comms) Team**

Dr. Allen Adler

Dr. Pete Swan

BG(Ret) Bob Wynn

Ms. Madhu Beriwal

**Surveillance & Reconnaissance (SR) Team**

Dr. Darrell Collier

Mr. Herb Gallagher

Mr. Gary Glaser

Mr. Steve Scalera

ROTC Cadet – Ms. Jolene Puthoff

# Agenda

- Terms of Reference
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- Communications Analysis
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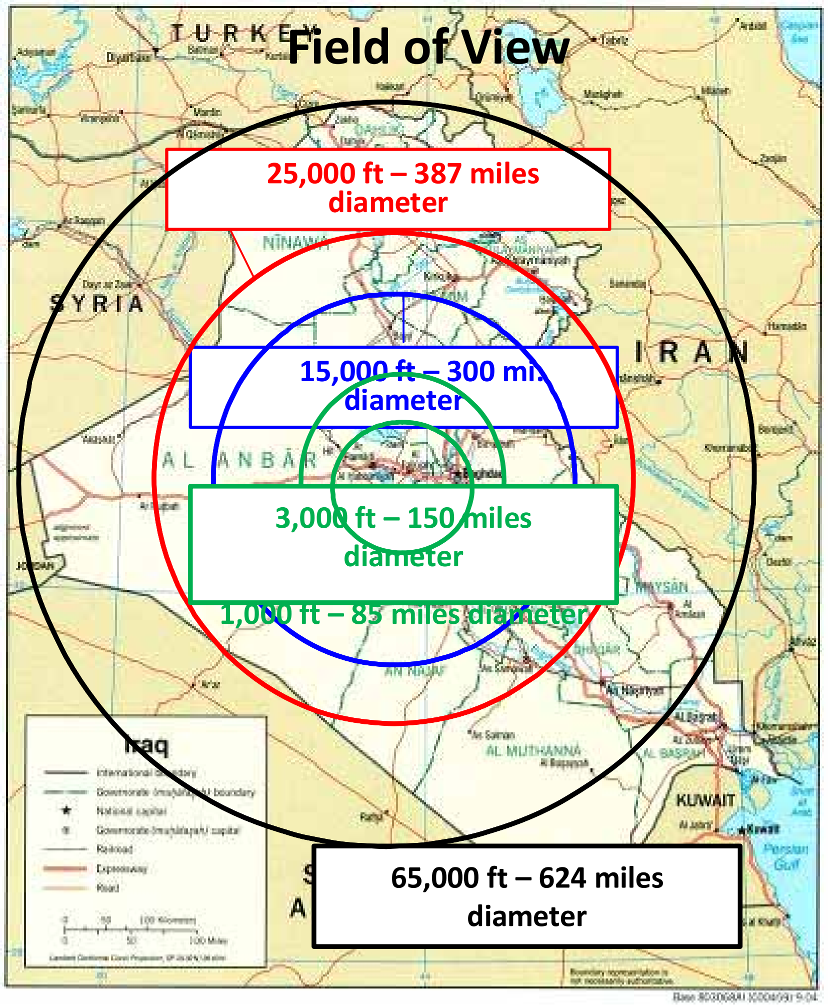
- Comparison of Comms and SR
- Analysis Conclusions
- Recommendations



# Persistent CSR Terms Of Reference

**The goal of this study is to suggest a concept and structure for best use of CSR assets, including reporting on:**

- What technical capabilities are possible from Space-based, “Near-Space” based, High-Altitude Long-Endurance UAV-based or Airship-based platforms?
- How do these capabilities compare to those available on lower altitude UAVs as well as ground-based and other assets?
- How does one trade off the benefits and weaknesses of each type of asset?
- To what degree can both the current and the future forces increase mobility and sustainability through integration and systematic use of such assets?
- To what degree do such platforms decrease the logistics and support burden for sustained operations?
- How does cost of each type of platform compare?

# Study Assumptions

- Assume current conflict/enemy
- Focus on 3–5 year timeframe
- Focus on unmanned air/space platforms
  - Assume existing/planned sensors and comms devices
  - Do not consider ground-based systems
- Focus on BCT and below
- SR in theater is near-real time, and SR comms links to-and-from platform are integral to the system
- Intelligence dissemination not considered
- Analysis of Comms and SR is done independently and then merged

# Visits/Contacts

## Army

SMDC/ARSTRAT
G-6 and G-2
Ft Hood (1st CAV/CTSF)
TRADOC HQ
Ft Huachuca
Ft Monmouth
Ft Belvoir NVL
Ft Gordon
TRAC
AMCOM
PEO Aviation
PM UAS

## Air Force

Kirtland AFB – Operationally Responsive Space (ORS)

Langley AFB – GCIC

## Industry

Lockheed Martin
Boeing
Raytheon
SkySentry
Blackwater

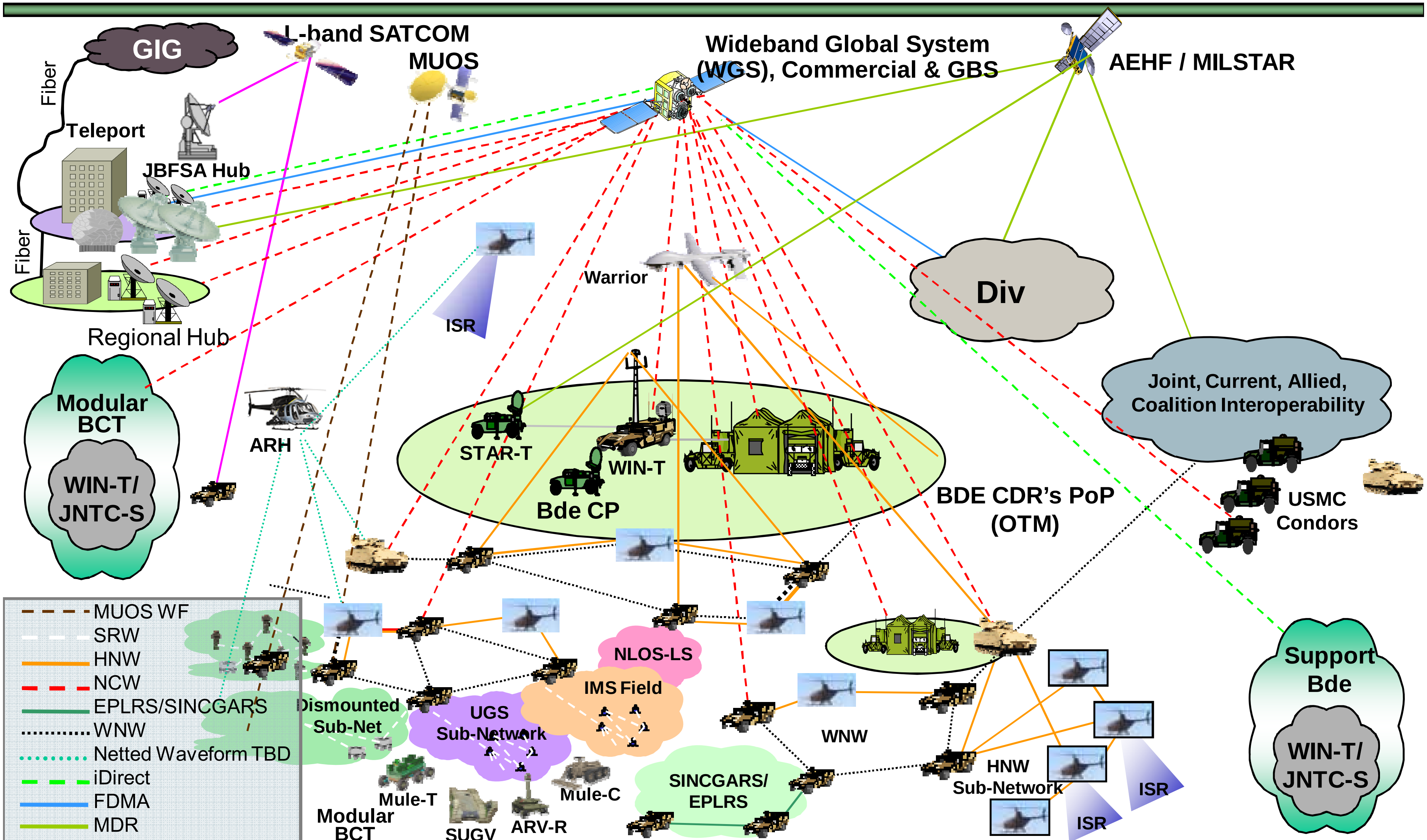
## Other

NGA
NRO
DARPA
MITRE
JFCOM HQ

# Key Findings from Visits

- Persistence is not well defined. The definition the study used: “If I have what I need, when I need it, for as long as I need it – it is persistent”
- Gaps in coverage and persistence exist
  - The disadvantaged user lacks adequate Comms Relay capability
  - Army highly dependent on costly commercial space platforms for Beyond Line of Sight (BLOS) Comms
  - Large aircraft (e.g., KC-135) could be utilized for Comms Relay
- Proponency for persistent CSR platforms is distributed
  - Multiple Joint Urgent Operational Needs Statements (JUONS) have been submitted resulting in multiple ad-hoc solutions
  - No integrated mission Analysis of Alternatives (AoA) was found
- SATs are not sufficiently responsive to BCT and below commanders
- For the CSR mission at BCT and below, unmanned platforms are increasingly effective and accepted
- There is a skepticism in the Army about employing untethered Lighter than Air (LTA) platforms
- Technological advances supporting untethered LTAs are emerging rapidly

# Communications Operational Overview (~2013)



# Analysis Model

| Platform Attributes | Weight Factors (1–5) | Platforms |
|---|---|---|

## Platform Attributes

- **Technical**
  - Vulnerability
  - Reconfigurability
  - Power
  - Payload Size
  - Time on Station
- **Mobility & Sustainability**
  - Mission Agility
  - Tactical Responsiveness
  - All Weather Ops
  - Airspace Mgt
  - Area of Coverage
- **Support Burden**
  - Support Infrastructure
  - User SWaP (Manpack)
- **Cost**
  - Acquisition Cost
  - Flying Hour Cost
  - TRL
  - Time to Market

## Weight Factors (1–5)

## Platforms

- **Fixed Wing (UAVs)**
  - Low Altitude – e.g.,Shadow/Firescout
  - Medium Altitude – e.g., Warrior
  - High Altitude – e.g.,Global Hawk
- **Lighter Than Air (LTAs)**
  - Low Altitude (Tethered) – e.g.,RAID
  - Low Altitude (Untethered) – e.g.,BA 71
  - Medium Altitude (Tethered) – e.g.,JLENS
  - Medium Altitude (Untethered) – e.g.,BA 145
  - High Altitude (Untethered) – e.g.,HAA
- **Satellites (SATs)**
  - Low Earth Orbit (LEO) Conventional – e.g.,Ikonos/Iridium
  - Innovative LEO – e.g.,TACSAT 2/ORS
  - Medium Earth Orbit (MEO) – e.g.,GPS
  - Geosynchronous Orbit (GEO) – e.g.,DSCS/UFO/ INMARSAT
- **Grading Factors** (1–4 shown as colors)

Notes:

- Sensitivity Analysis
- Observations

# Grading Factor Criteria

| Attributes \ Criteria | Red - 1 | Yellow - 2 | Green - 3 | Blue - 4 |
|---|---|---|---|---|
| Vulnerability* | Small Arms & MANPAD Dest. | Small Arms & MANPAD Damage | Mobile SAMs | Fixed SAMs |
| Reconfigurability | << Warrior | < Warrior | Warrior | > Warrior |
| Power (Platform/User) | < 50 watts<br>> 200 watts | 50 – 300 watts<br>20 – 200 watts | 300 – 2K watts<br>5 – 20 watts | 2K watts<br>< 5 watts |
| Payload Size (Platform/User) | < 75 lbs<br>Fixed Station | 75 – 200 lbs<br>Vehicle Mounted | 200 – 500 lbs<br>Manpack | > 500 lbs<br>Handheld |
| Time on Station | < 12 hrs | 12 hrs – 36 hrs | 36 hrs – 10 days | > 10 days |
| Mission Agility | << Warrior | < Warrior | Warrior | > Warrior |
| Responsiveness | << Warrior | < Warrior | Warrior | > Warrior |
| All Weather Ops | << Warrior | < Warrior | Warrior | > Warrior |
| Airspace Mgt* | Restrictions | VFR Controlled | Part of ATO | Outside of ATO |
| Coverage Area* | < 5K Altitude | 5K – 10K Altitude | 10K – 25K Altitude | > 30K Altitude |
| Spt Infrastructure | << Warrior | < Warrior | Warrior | > Warrior |
| SWaP/Manpack | Not Voice Capable | Voice Capable | Image Capable | Video Capable |
| Acquisition Cost | > $50M | $10M – $50M | $1M – $10M | < $1M |
| Flying Hr Cost | > $20K | $5K – $20K | $1K – $5K | < $1K |
| TRL | 4 or less | 5 – 6 | 7 – 8 | 9 or greater |
| Time to Market | > 1 year | < 1 year | Some Deployment | Widely Deployed |

* Decrement 1 Color for Tether

# Analysis Model

| Platform Attributes | | Platforms |
|---|---|---|
| | | |

## Platform Attributes

- **Technical**
  - Vulnerability
  - Reconfigurability
  - Power
  - Payload Size
  - Time on Station
- **Mobility & Sustainability**
  - Mission Agility
  - Tactical Responsiveness
  - All Weather Ops
  - Airspace Mgt
  - Area of Coverage
- **Support Burden**
  - Support Infrastructure
  - User SWaP (Manpack)
- **Cost**
  - Acquisition Cost
  - Flying Hour Cost
  - TRL
  - Time to Market

## Weight Factors (1–5)

## Platforms

- **Fixed Wing (UAVs)**
  - Low Altitude – e.g.,Shadow/Firescout
  - Medium Altitude – e.g., Warrior
  - High Altitude – e.g.,Global Hawk
- **Lighter Than Air (LTAs)**
  - Low Altitude (Tethered) – e.g.,RAID
  - Low Altitude (Untethered) – e.g.,BA 71
  - Medium Altitude (Tethered) – e.g.,JLENS
  - Medium Altitude (Untethered) – e.g.,BA 145
  - High Altitude (Untethered) – e.g.,HAA
- **Satellites (SATs)**
  - Low Earth Orbit (LEO) Conventional – e.g.,Ikonos/Iridium
  - Innovative LEO – e.g.,TACSAT 2/ORS
  - Medium Earth Orbit (MEO) – e.g.,GPS
  - Geosynchronous Orbit (GEO) – e.g.,DSCS/UFO/INMARSAT
- **Grading Factors** (1–4 shown as colors)

Notes:

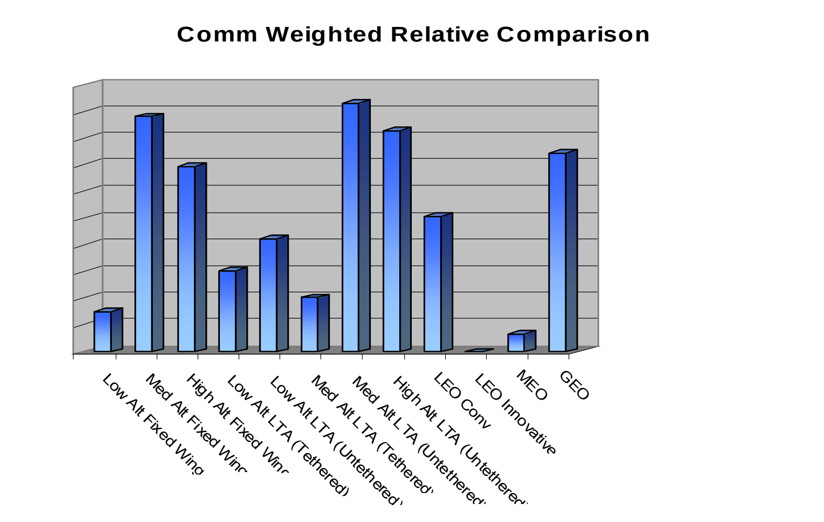
- Sensitivity Analysis
- Observations

# Persistent Communications Platform Analysis

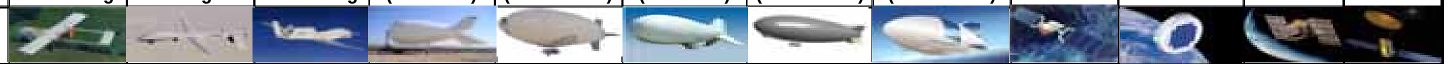
| | Weight Factor | Low Alt Fixed Wing | Med Alt Fixed Wing | High Alt Fixed Wing | Low Alt LTA (Tethered) | Low Alt LTA (Untethered) | Med Alt LTA (Tethered) | Med Alt LTA (Untethered) | High Alt LTA (Untethered) | LEO Conv | LEO Innovative | MEO | GEO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vulnerability | 5 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Reconfigurability | 3 | 2 | 3 | 2 | 4 | 4 | 2 | 4 | 2 | 1 | 1 | 1 | 1 |
| Power | 3 | 2 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 1 | 3 | 3 |
| Payload Size | 3 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 1 | 3 | 3 |
| Time on Station | 5 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 4 | 1 | 1 | 1 | 4 |
| Mission Agility | 1 | 2 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 1 | 1 | 1 | 3 |
| Tactical Responsiveness | 3 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 1 | 2 | 1 | 1 |
| All weather Ops | 5 | 1 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 4 |
| Airspace Mgt | 1 | 2 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Area of Coverage | 5 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Support Infrastructure | 3 | 4 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| User SWAP (Manpack) | 5 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 1 | 1 | 2 |
| Acquisition Cost | 2 | 4 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 |
| Flying Hour Cost | 3 | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 2 |
| TRL | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 1 | 4 | 1 | 1 | 4 |
| Time to Market | 3 | 4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 4 | 1 | 1 | 4 |

## Observations

- Highest valued platforms: Med & High Alt LTA (Untethered), Med & High Alt UAVs and GEO SATs
- High altitude long endurance LTA (Untethered) has promising high payoff but has technical risk
- Lowest valued platforms: Innovative LEO, MEO SATs and Low Alt Fixed Wing



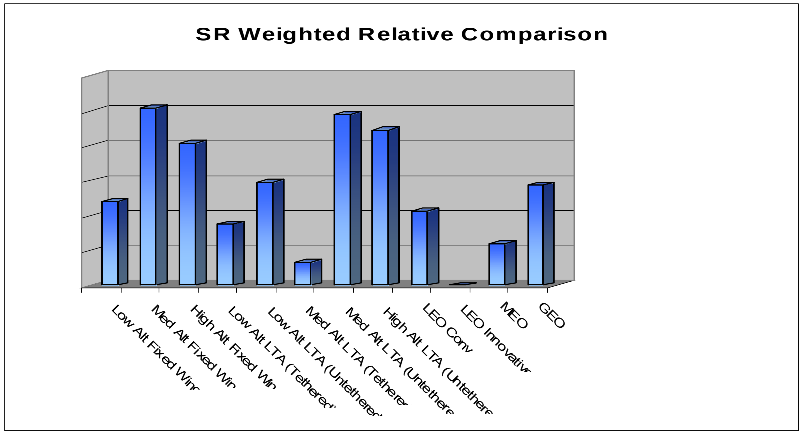
# Persistent Surveillance & Reconnaissance Platform Analysis



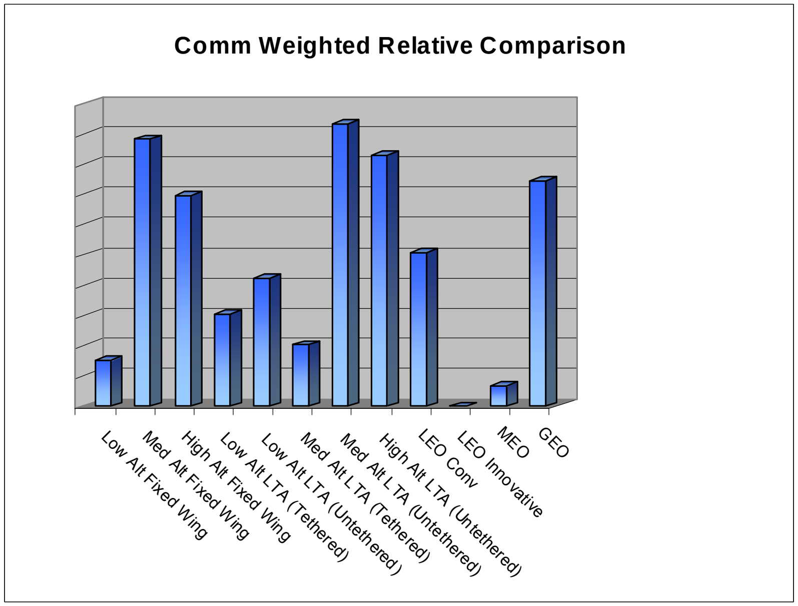
| | Weight Factor | Low Alt Fixed Wing | Med Alt Fixed Wing | High Alt Fixed Wing | Low Alt LTA (Tethered) | Low Alt LTA (Untethered) | Med Alt LTA (Tethered) | Med Alt LTA (Untethered) | High Alt LTA (Untethered) | LEO Conv | LEO Innovative | MEO | GEO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vulnerability | 3 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Reconfigurability | 3 | 2 | 3 | 2 | 4 | 4 | 2 | 4 | 2 | 1 | 1 | 1 | 1 |
| Power | 1 | 2 | 3 | 3 | 4 | 3 | 4 | 3 | 4 | 4 | 1 | 3 | 3 |
| Payload Size | 2 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 1 | 3 | 3 |
| Time on Station | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 4 | 1 | 1 | 1 | 4 |
| Mission Agility | 3 | 2 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 1 | 1 | 2 | 1 |
| Tactical Responsiveness | 5 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 1 | 2 | 1 | 1 |
| All weather Ops | 5 | 1 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 4 |
| Airspace Mgt | 2 | 2 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Area of Coverage | 3 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Support Infrastructure | 3 | 4 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| User SWaP (Manpack) | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 1 | 1 | 2 |
| Acquisition Cost | 2 | 4 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 |
| Flying Hour Cost | 3 | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 2 |
| TRL | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 1 | 4 | 1 | 4 | 4 |
| Time to Market | 4 | 4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 4 | 1 | 1 | 4 |

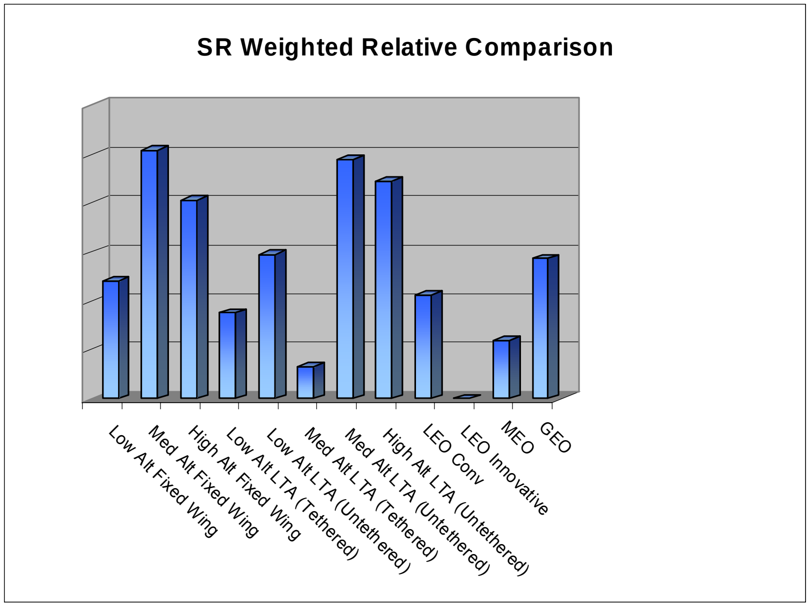
## Observations

- Highest valued platforms: Med & High Alt LTA (Untethered) and Med & High Alt UAVs
- High altitude long endurance LTA (Untethered) has promising high payoff but has technical risk
- Lowest valued platforms: Med Alt LTA (Tethered) and Innovative LEO



# Comparison of Persistent Comms & SR




## Observations

- Med & High Alt platforms rate the best for both Comms and SR
- Fixed wing and LTA (Untethered) are comparable for the same altitude
  - Offer potential opportunities for shared/integrated platform use
- Innovative LEO scored low for Persistent Comms & SR
- GEO SATs did better for Comms than SR

# Analysis Conclusions

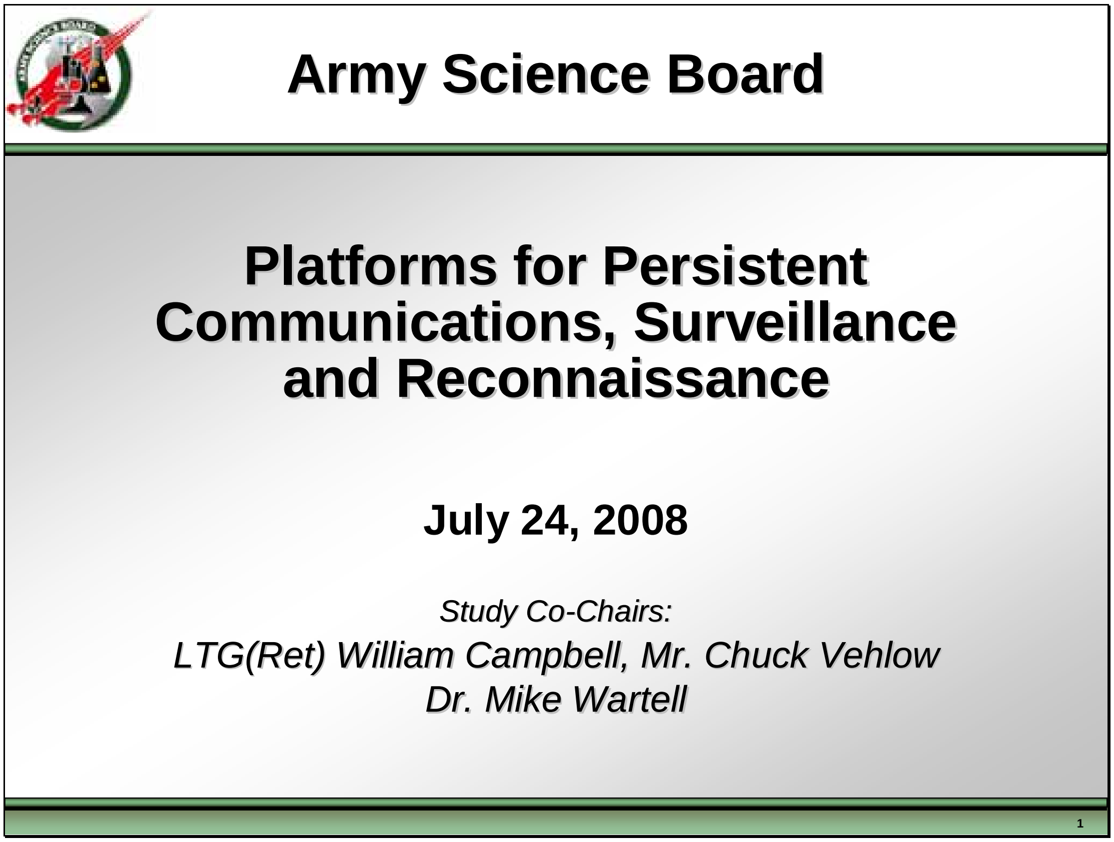
- **Medium and High Altitude LTA airships (untethered) total scores were about equal to or better than UAVs at comparable altitudes for Persistent CSR** because of reconfigurability, time on station, payload size and flying hour costs for medium altitude and time on station, support infrastructure and flying hour costs for high altitude.
- **Medium altitude LTA airships offer promising capabilities for CSR in the near term** due to rapidly maturing capabilities based on a number of factors including time on station, all weather capability, flying hour cost and vulnerability
- **LTA aerostats (tethered) compared poorly to LTA airships (untethered)** because of vulnerability, support infrastructure, altitude limitations, and weather sensitivities.
- **For Persistent CSR, Innovative LEO did not rate well** because of limited time on station
- **GEO SATs have high potential value** which is offset by high acquisition costs and Space Weight and Power (SWaP) requirements of user terminals

**As a result,**

- **High altitude LTA and UAV platforms permit offload of communication traffic from high cost commercial satellites and future military satellites (e.g.,TSAT)**
- **The maturation and potential payoff of LTA technology warrants further investment in experimentation and potential acquisition because of persistence on station**

# Recommendations

- Assign proponency for LTA in the controlled airspace to the Aviation Center. TRADOC
  - SMDC should retain proponency for High Altitude
- Accelerate employment of Medium Altitude LTA (untethered) prototypes for joint CSR experiments in operational environments (e.g., Ft Bliss, JEFX) ASA(ALT)
- Increase the investment in technology to mature High Altitude LTA airships for use as CSR platforms. ASA(ALT)
- Form collaborative LTA Integrated Product Team (IPT) of technologists, material developers, and combat developers ASA(ALT)/G-3
- Conduct an integrated AOA that includes persistent comms and SR payloads, UAV and LTA platforms, large Aircraft (e.g., KC-135), and commercial and military satellites that explicitly addresses alternative mixes of capabilities. TRADOC




The sponsor for this study is the Commander of the USA SMDC/ARSTRAT, LTG Kevin Campbell. The Acting Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA ALT), Mr. Dean Popps, requested the ASB perform a study to assess the viability of unmanned platforms to provide for persistent Communications, Surveillance and Reconnaissance in current conflict scenarios.

His guidance focused the study on echelons from the BCT and below.

# Persistent CSR Study Membership

**CO-CHAIRS**

**LTG(Ret) William Campbell** **Mr. Chuck Vehlow** **Dr. Mike Wartell**

**STUDY TEAMS**

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Mr. Herb Gallagher

Mr. Gary Glaser

Mr. Steve Scalera

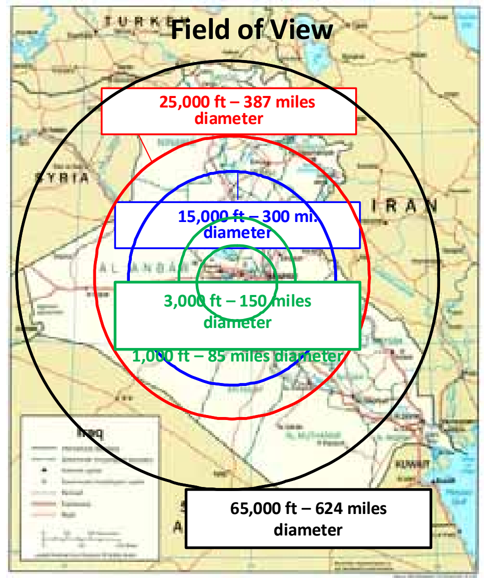
ROTC Cadet – Ms. Jolene Puthoff

Persistent CSR 1

The study team consisted of a diverse set of professionals with military, business and academic credentials with the disciplines of engineering, science, and communications and sensor/radar systems. Detailed backgrounds can be found in the ASB Biography Handbook. Mr. Tom Pagan, Deputy Chief Scientist, served as the USA SMDC / ARSTRAT Command principal study representative and technical advisor to the study.

## Agenda

- Terms of Reference
- Study Assumptions
- Visits/Contacts
- Key Findings from Visits
- Operational Overview
- Analysis Model
- Grading Criteria
- Communications Analysis
- S&R Analysis
- Comparison of C and SR
- Analysis Conclusions
- Recommendations




Persistent CSR 3

The presentation follows the agenda shown in the above chart. The study panel used meetings, visits, and research to collect an updated baseline of information, used the baseline to develop and implement an analysis process, and used the results as the basis for conclusions and recommendations.

The figure shows the coverage from platforms at various altitudes. The persistent Communications/SR missions are dependent on their coverage and the types of payloads. This study will look at platform alternatives, much of which is related to coverage as seen inside the various circles. Note, the coverage of satellites is far greater than air sensors and is not represented in the figure.

## Persistent CSR Terms Of Reference

**The goal of this study is to suggest a concept and structure for best use of CSR assets, including reporting on:**

- What technical capabilities are possible from Space-based, “Near-Space” based, High-Altitude Long-Endurance UAV-based or Airship-based platforms?
- How do these capabilities compare to those available on lower altitude UAVs as well as ground-based and other assets?
- How does one trade off the benefits and weaknesses of each type of asset?
- To what degree can both the current and the future forces increase mobility and sustainability through integration and systematic use of such assets?
- To what degree do such platforms decrease the logistics and support burden for sustained operations?
- How does cost of each type of platform compare?

Persistent CSR 4

Expanding situational awareness and facilitating communications among units allows all types of modular brigades to enjoy greater mobility, especially if communications can be maintained while “on-the-move” and in austere environments. Such capability will also improve reachback for support from non-organic fires and intelligence. Obtaining the best balance between performance, mobility and supportability of communications and sensing capabilities is critical to enhancing the effectiveness of combat units at every level of command. The goals of this study are shown above. The entire TOR is in Appendix A.

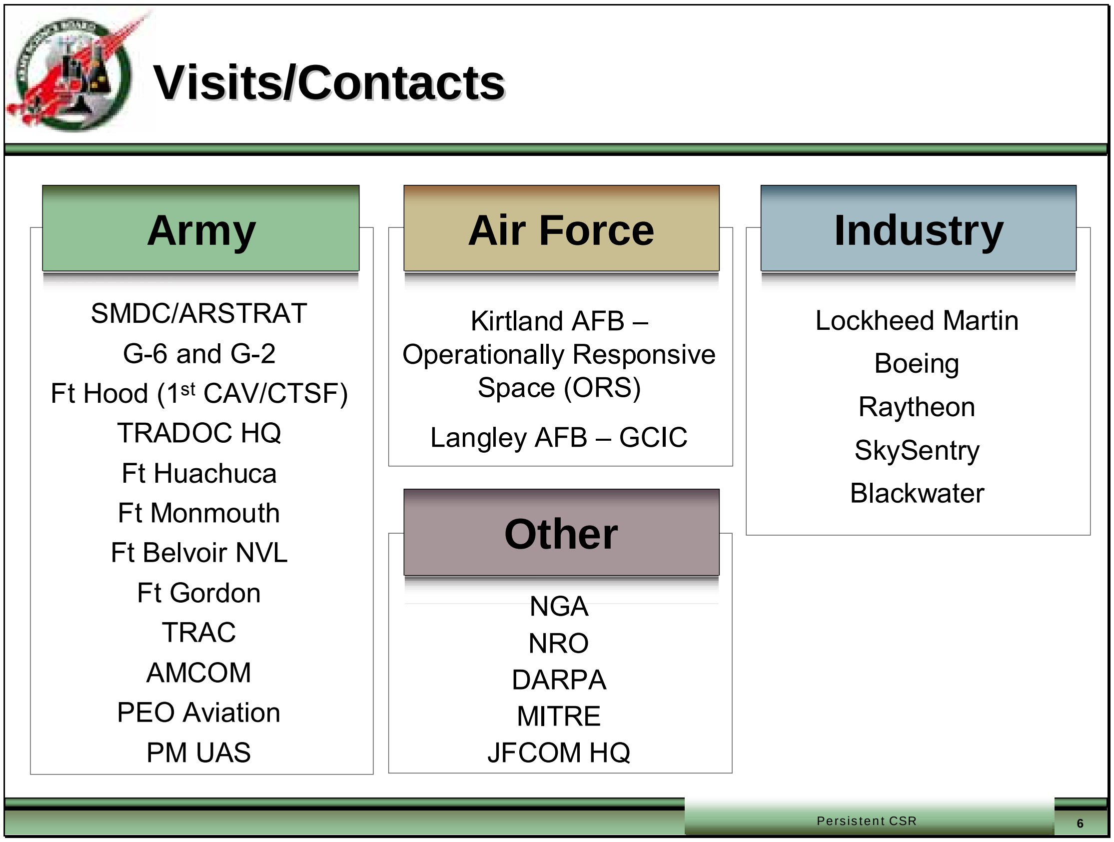
## Study Assumptions

- Assume current conflict/enemy
- Focus on 3-5 year timeframe
- Focus on unmanned air/space platforms
  - Assume existing/planned sensors and comms devices
  - Do not consider ground-based systems
- Focus on BCT and below
- SR in theater is near-real time, and SR comms links to-and-from platform are integral to the system
- Intelligence dissemination not considered
- Analysis of Comms and SR is done independently and then merged

Persistent CSR 5

The study was bounded by some key assumptions as noted above. The mission was constrained to the current conflict and enemies, and the current phase of the campaign. Focus of the required persistent CSR support was to the BCT and below with the disadvantaged user of key importance. Unmanned platforms were the primary focus. It was assumed that the Communications and SR payloads fit within the platform size, weight and power constraints.

The technologies to be considered should result in system implementation within a three to five year timeframe. The study began its analysis with two sub panels – Communications and Surveillance & Reconnaissance. After providing detailed analysis and associated results for each of the two separate areas, the results were merged and integrated to ensure findings to both mission areas were ascertained.




This study started with the review of previous studies and documents conducted by NASA, Navy, Air Force and Army. The panel met with a variety of organizations in addition to reviewing previous reports and in-house briefings. The organizations included technology, material development, and combat development entities along with warfighters with recent OIF/OEF experience. Participation included both Army and Air Force organizations in addition to three DoD agencies – DARPA, NGA, and NRO. Five companies intimately involved in the development of Lighter than Air (LTA) platforms provided their current status in development and associated technology.

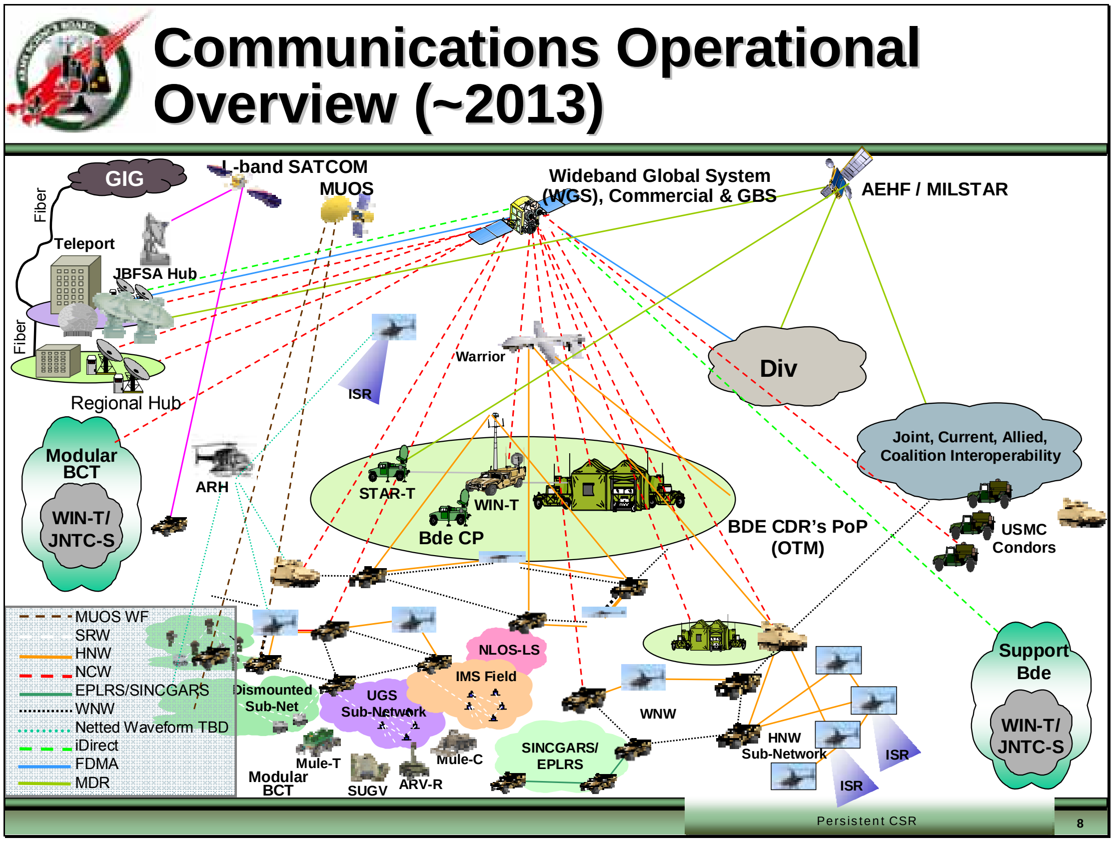
## Key Findings from Visits

- Persistence is not well defined. The definition the study used:
  "If I have what I need, when I need it, for as long as I need it – it is persistent"
- Gaps in coverage and persistence exist
  - The disadvantaged user lacks adequate Comms Relay capability
  - Army highly dependent on costly commercial space platforms for Beyond Line of Sight (BLOS) Comms
  - Large aircraft (e.g., KC-135) could be utilized for Comms Relay
- Proponency for persistent CSR platforms is distributed
  - Multiple Joint Urgent Operational Needs Statements (JUONS) have been submitted resulting in multiple ad-hoc solutions
  - No integrated mission Analysis of Alternatives (AoA) was found
- SATs are not sufficiently responsive to BCT and below commanders
- For the CSR mission at BCT and below, unmanned platforms are increasingly effective and accepted
- There is a skepticism in the Army about employing untethered Lighter than Air (LTA) platforms
- Technological advances supporting untethered LTAs are emerging rapidly

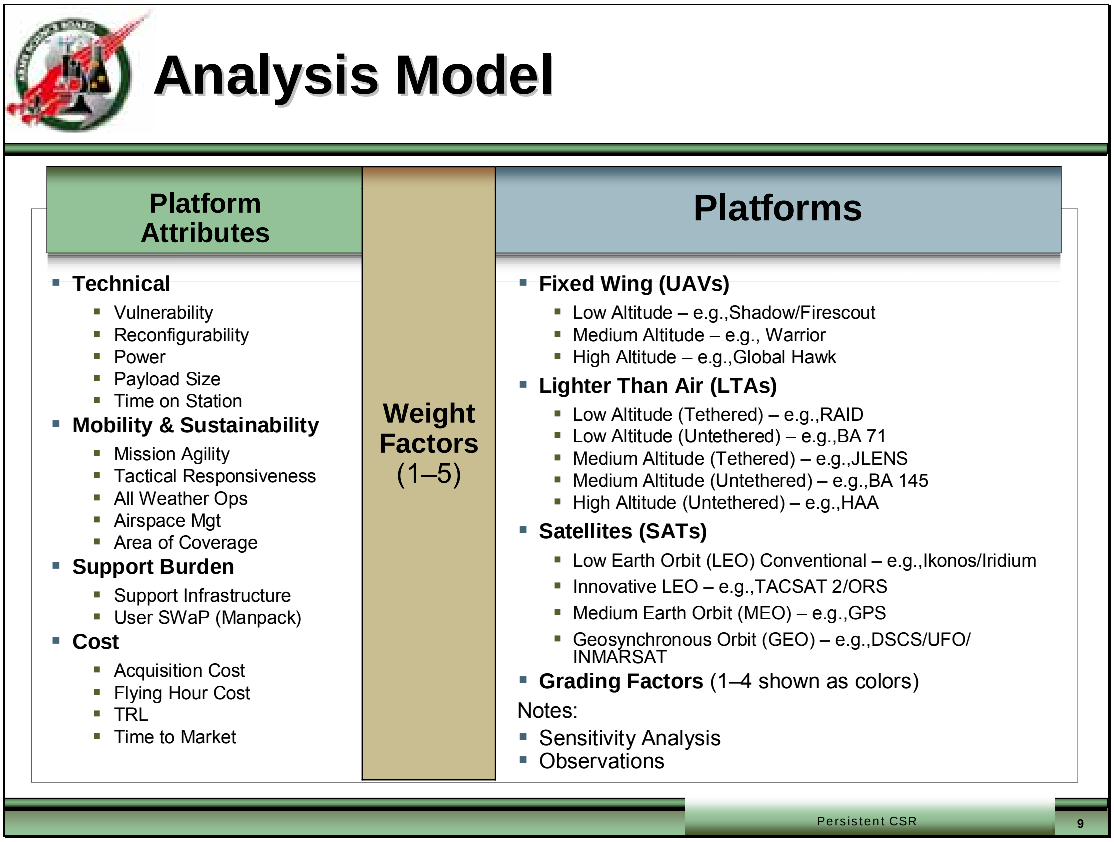
Persistent CSR 7

During visits, briefers presented their cases. Each showed the trade spaces they were involved in and proposed approaches for persistent Communications and SR. Fallout from these visits includes an understanding of the "as is" situation and a better understanding of the problem. After combining the panel inputs and individual perceptions of what we heard, key findings, as shown above, surfaced.

During these interfaces, it became clear to the study panel that the definition of persistent varied from organization to organization and mission to mission, leading the Panel to define it as above. It also became evident that there is a lack of integrated analysis and/or trade studies that included the different platforms. Despite advances in LTA technologies, the panel noted skepticism within the Army ("giggle factor") that impeded full consideration as CSR platforms, similar to attitudes toward UAVs in years past.




This slide shows a graphic representation of expected operational communications in the 2013 timeframe.




The assessment model developed for this study considered sixteen key platform attributes which can be separated into four general assessment areas suggested by the TOR:

- The technical capability of the platform to achieve the study goal of persistence with regard to its vulnerability to the environment; its ability to accept different payloads and perform differing missions; maintaining sufficient power for both longevity and agility; sufficient payload capacity consistent with altitude and payload configuration; and both technical and engineering design to enable prolonged on-station operations.

- The operational platform mobility and its capability to sustain the rigors of varying environments have profound implications to overall platform mission operations. These attributes are mission agility; tactical responsiveness; all weather operations; airspace management; and area of coverage. Since this study is keyed to persistent support to the BCT and below, responsiveness of the platform and its requisite payload to the appropriate tactical combat commander is a need currently not filled. Agility of the platform overlaid with its overall innate area of coverage is a requisite need to enable persistent Comms and provide for localized SR to the particular echelon.

- Support burden refers to both the logistical and operational infrastructure support required to transport, operate, and maintain the platform. A key factor is the size of the crew necessary for operations that may include 24/7 for long periods of time.

- Also to be considered is force protection required of some platform operations. In addition to Size, Weight and Power (SWaP) as it relates to the platform operational needs, consideration must be given to the trades associated with potential payload designs due to payload distance from users. This can affect both onboard platform SWaP parameters and in the case of Comms, ground based systems.

- The two major cost areas influencing the selection of particular platforms are the acquisition cost and its operational cost characterized by flying hour cost. The technology maturity is reflected in the platform TRL status. Time to market of the platform reflects availability to the force and deployment within the force.

The model used in this assessment takes the twelve platforms listed in the chart and grades each of the platforms against each of the attributes on a scale of 1 to 4 with 4 denoting relative score of high for the given attribute. This grading uses information gained from those reports listed in the included bibliography, discussion with outside experts, and detailed review by the panel members. The evaluation considered the medium altitude UAV Warrior as the reference platform with the grading scores of the other platforms lower, equal, or higher than the reference within the scoring range of 1 to 4. See the next chart for the grading criteria. Additionally, a weighting factor was assigned to each attribute for each of the two missions considered – one set for Comms, and one set for SR. The scale was set at 1 to 5, with the relative scale of 5 being of highest importance for the particular attribute within the given mission area. The results of the attribute grading and the application of the weighting factors provided relative scores for each platform which could then be compared to determine the relative value of each platform in both the Comms and the SR mission areas.

## Grading Factor Criteria

| Attributes \ Criteria | Red - 1 | Yellow - 2 | Green - 3 | Blue - 4 |
|---|---|---|---|---|
| **Vulnerability*** | Small Arms & MANPAD Dest. | Small Arms & MANPAD Damage | Mobile SAMs | Fixed SAMs |
| **Reconfigurability** | << Warrior | < Warrior | Warrior | > Warrior |
| **Power (Platform/User)** | < 50 watts<br>> 200 watts | 50 – 300 watts<br>20 – 200 watts | 300 – 2K watts<br>5 – 20 watts | 2K watts<br>< 5 watts |
| **Payload Size (Platform/User)** | < 75 lbs<br>Fixed Station | 75 – 200 lbs<br>Vehicle Mounted | 200 – 500 lbs<br>Manpack | > 500 lbs<br>Handheld |
| **Time on Station** | < 12 hrs | 12 hrs – 36 hrs | 36 hrs – 10 days | > 10 days |
| **Mission Agility** | << Warrior | < Warrior | Warrior | > Warrior |
| **Responsiveness** | << Warrior | < Warrior | Warrior | > Warrior |
| **All Weather Ops** | << Warrior | < Warrior | Warrior | > Warrior |
| **Airspace Mgt*** | Restrictions | VFR Controlled | Part of ATO | Outside of ATO |
| **Coverage Area*** | < 5K Altitude | 5K – 10K Altitude | 10K – 25K Altitude | > 30K Altitude |
| **Spt Infrastructure** | << Warrior | < Warrior | Warrior | > Warrior |
| **SWaP/Manpack** | Not Voice Capable | Voice Capable | Image Capable | Video Capable |
| **Acquisition Cost** | > $50M | $10M – $50M | $1M – $10M | < $1M |
| **Flying Hr Cost** | > $20K | $5K – $20K | $1K – $5K | < $1K |
| **TRL** | 4 or less | 5 – 6 | 7 – 8 | 9 or greater |
| **Time to Market** | > 1 year | < 1 year | Some Deployment | Widely Deployed |

* Decrement 1 Color for Tether

Persistent CSR 10

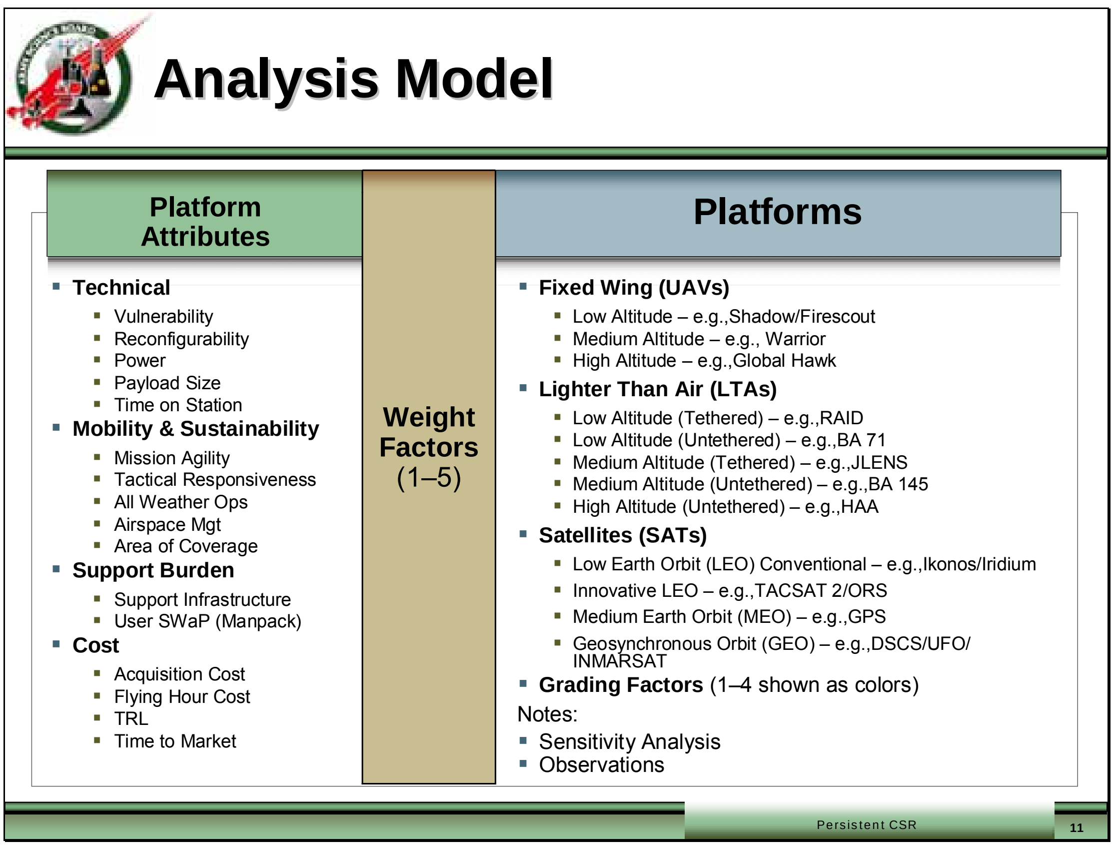
The criteria for grading the platform attributes in this study are contained in the above chart. As was stated before, the scaling is 1 to 4 with the base reference system the medium altitude UAV WARRIOR. The WARRIOR grading is presented in the Green (3) column and the remaining three columns (1, 2, 4) are referenced to this. The breakpoints within each grading area were independently derived based upon information gleaned from both the documentation contained in the bibliography, discussions with experts presenting material to the panel, and in-depth deliberations among the panel members.

As shown, eight criteria can be referenced to definitive metric (quantitative) values. The separation of values was keyed to the WARRIOR as equal to, greater than, or less than the stated ranges. As an example, the payload capability for the WARRIOR is in the 200 to 500 pound range. The SHADOW is given a grade of 1 (red) with its < 75 pound capability and a medium altitude LTA (e.g., JLENS) has a grade of 4 (blue) with a payload range of > 500 pounds. These grades characterize the ability of the platform to carry sensor and/or Comms payloads. For example, the SHADOW has a smaller payload capability as related to WARRIOR and is graded a 1 as opposed to a JLENS (grade 4) which can carry a larger payload.

The other eight criteria have implicit quantitative and qualitative values which have been considered in deriving a quantitative grading representation. For example, because of its operational altitude the WARRIOR platform is susceptible to vehicle mounted SAMs but too high to be challenged with small arms and MANPADs. Hence, the grading is 3 (green). The SHADOW, which operates at low altitude, is susceptible to small arms fire so its vulnerability is graded as 1 (red). The higher altitude platforms, such as High Altitude Airships or GLOBAL HAWK, are susceptible to fixed SAMs which are not included in the inventory of the enemy considered in the current conflict and results in a grading of 4 (blue).

For three of the criteria (vulnerability, airspace management, coverage area), the tethered LTAs were decremented by one grade due to the increased issues created by the tether and its associated fixed ground facilities.

The grading for each of the criteria are incorporated in the following charts – (1) PERSISTENT COMMUNICATIONS, and (2) PERSISTENT SURVEILLANCE & RECONNAISSANCE.




For each platform type, the panel took the weighted sum of the grading factors, normalized them and represented them graphically in order to compare them. This was done separately for Comms and SR. The grading factors and weights were varied in order to determine the sensitivities of the results to those changes. The results increased the panels' confidence in the analysis. Further, the Saaty Analytic Hierarchy Process (AHP) was used to further validate the results.

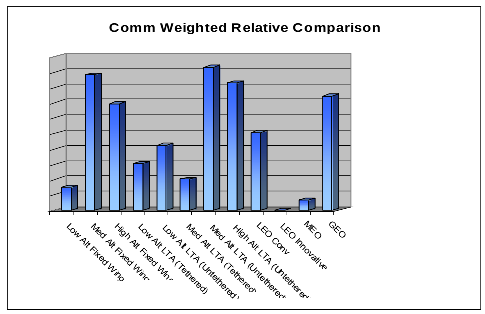
The following two charts present the results of the assessment, one for persistent communications and one for persistent surveillance and reconnaissance.

## Persistent Communications Platform Analysis

| | Weight Factor | Low Alt Fixed Wing | Med Alt Fixed Wing | High Alt Fixed Wing | Low Alt LTA (Tethered) | Low Alt LTA (Untethered) | Med Alt LTA (Tethered) | Med Alt LTA (Untethered) | High Alt LTA (Untethered) | LEO Conv | LEO Innovative | MEO | GEO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vulnerability | 5 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Reconfigurability | 3 | 2 | 3 | 2 | 4 | 4 | 2 | 4 | 2 | 1 | 1 | 1 | 1 |
| Power | 3 | 2 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 1 | 3 | 3 |
| Payload Size | 3 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 1 | 3 | 3 |
| Time on Station | 5 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 4 | 1 | 1 | 1 | 4 |
| Mission Agility | 1 | 2 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 1 | 1 | 1 | 3 |
| Tactical Responsiveness | 3 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 1 | 2 | 1 | 1 |
| All weather Ops | 5 | 1 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 4 |
| Airspace Mgt | 1 | 2 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Area of Coverage | 5 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Support Infrastructure | 3 | 4 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| User SWAP (Manpack) | 5 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 1 | 1 | 2 |
| Acquisition Cost | 2 | 4 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 |
| Flying Hour Cost | 3 | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 2 |
| TRL | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 1 | 4 | 1 | 1 | 4 |
| Time to Market | 3 | 4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 4 | 1 | 1 | 4 |

### Observations

- Highest valued platforms: Med & High Alt LTA (Untethered), Med & High Alt UAVs and GEO SATs
- High altitude long endurance LTA (Untethered) has promising high payoff but has technical risk
- Lowest valued platforms: Innovative LEO, MEO SATs and Low Alt Fixed Wing




Persistent CSR 12

The above chart summarizes the results of the Panel's subjective, but systematic process to evaluate alternative platforms for hosting a communications relay. The estimated uncertainty in the scoring of each cell is within +/- 1 level, based on the criteria. As previously mentioned, weighting factors were estimated for each of the attributes. Higher weights were given to attributes that directly contribute to assured persistence needed for a communications relay. Lower weights were given to rapid agility as is consistent with the relay mission. When the weighted attribute scores are summed, the results are shown on the bar graph.

The highest scoring platform solutions are medium and high altitude LTAs (untethered) and UAVs along with GEO SATs. For the medium altitude solutions, the scoring reflects balanced strength among all of the attributes and few areas of weakness. For the high altitude untethered LTAs, the weaknesses reflect relatively immature technology readiness levels indicating risk. GEO SAT scored high for persistence and large payloads but had limited tactical responsiveness to the BCT, high acquisition costs and low user SWaP.

The lowest valued platforms are non-GEO satellites because of orbit-driven lack of persistence and low altitude UAVs because of small area coverage.

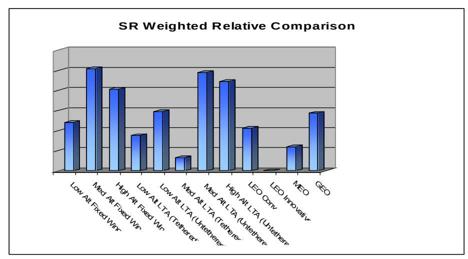
The highest scoring platforms scored well on a number of attributes.

# Persistent Surveillance & Reconnaissance Platform Analysis

| | Weight Factor | Low Alt Fixed Wing | Med Alt Fixed Wing | High Alt Fixed Wing | Low Alt LTA (Tethered) | Low Alt LTA (Untethered) | Med Alt LTA (Tethered) | Med Alt LTA (Untethered) | High Alt LTA (Untethered) | LEO Conv | LEO Innovative | MEO | GEO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vulnerability | 3 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Reconfigurability | 3 | 2 | 3 | 2 | 4 | 4 | 2 | 4 | 2 | 1 | 1 | 1 | 1 |
| Power | 1 | 2 | 3 | 3 | 4 | 3 | 4 | 3 | 4 | 4 | 1 | 3 | 3 |
| Payload Size | 2 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 1 | 3 | 3 |
| Time on Station | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 4 | 1 | 1 | 1 | 4 |
| Mission Agility | 3 | 2 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 1 | 1 | 2 | 1 |
| Tactical Responsiveness | 5 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 1 | 2 | 1 | 1 |
| All weather Ops | 5 | 1 | 3 | 4 | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 4 |
| Airspace Mgt | 2 | 2 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Area of Coverage | 3 | 1 | 3 | 4 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| Support Infrastructure | 3 | 4 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| User SWaP (Manpack) | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 1 | 1 | 2 |
| Acquisition Cost | 2 | 4 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 |
| Flying Hour Cost | 3 | 4 | 3 | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 2 |
| TRL | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 1 | 4 | 1 | 4 | 4 |
| Time to Market | 4 | 4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 4 | 1 | 1 | 4 |

## Observations

- Highest valued platforms: Med & High Alt LTA (Untethered) and Med & High Alt UAVs
- High altitude long endurance LTA (Untethered) has promising high payoff but has technical risk
- Lowest valued platforms: Med Alt LTA (Tethered) and Innovative LEO

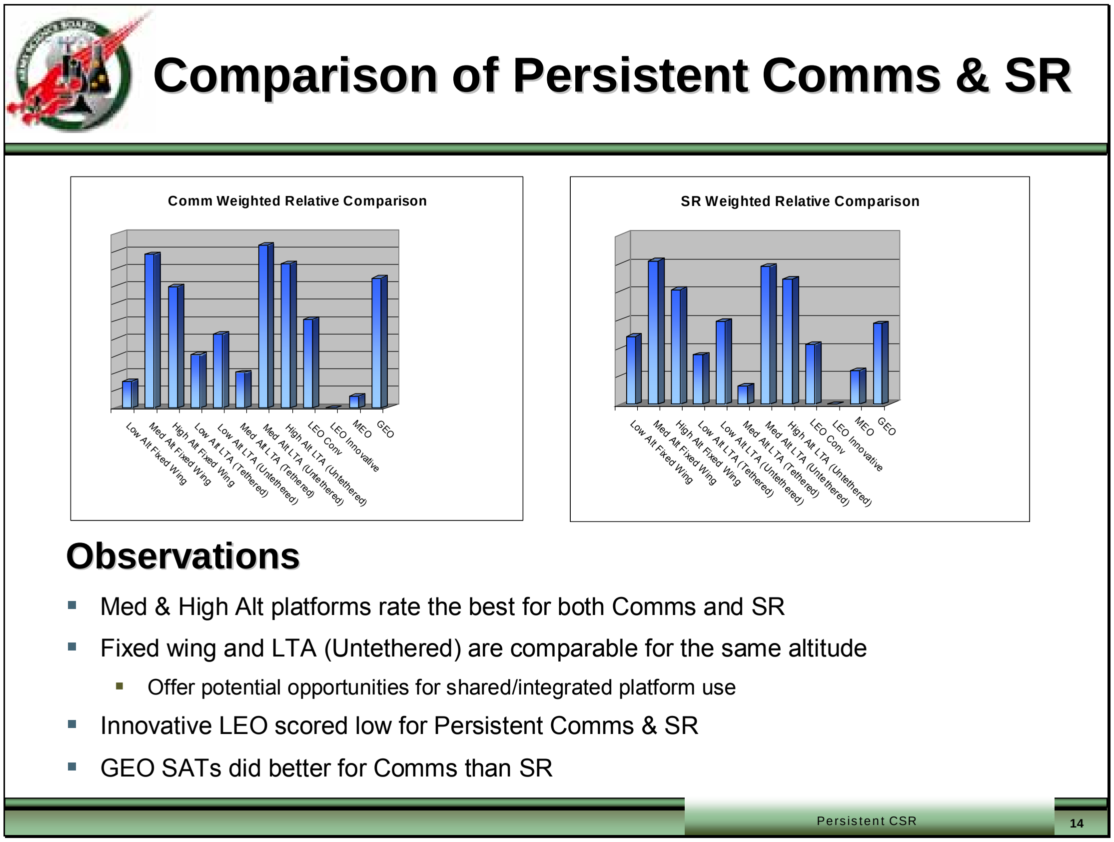



Persistent CSR 13

In a similar fashion, the above chart summarizes the results of evaluating alternative platforms for hosting surveillance and reconnaissance sensors. The same evaluation criteria were used but the weighting factors were adjusted to measure the value of the attributes that directly contribute to persistent SR. Higher weights were given to factors like tactical responsiveness, all weather operations and user Space, Weight and Power (SWaP) considerations while lower weights were given to factors like platform power. The results are shown on the above bar graph.

Like communications, the highest scoring platform solutions are medium and high altitude LTAs (untethered) and UAVs. The medium altitude solutions continue to show balanced strength among all of the attributes and few areas of weakness, while the high altitude platforms show great operational potential but reflect relatively immature technology readiness levels indicating risk.

The lowest valued platforms are non-GEO satellites because of orbit-driven lack of persistence, and medium altitude LTAs (tethered) because of their lack of mission agility and the support infrastructure necessary for the ground sites associated with tethered LTAs.




The summary charts from the two previous slides are presented here to provide a side-by-side comparison of the scores for communications and surveillance & reconnaissance. As can be seen, there is a great deal of similarity to the results. Platforms tend to be judged about the same for both applications within a small variation.

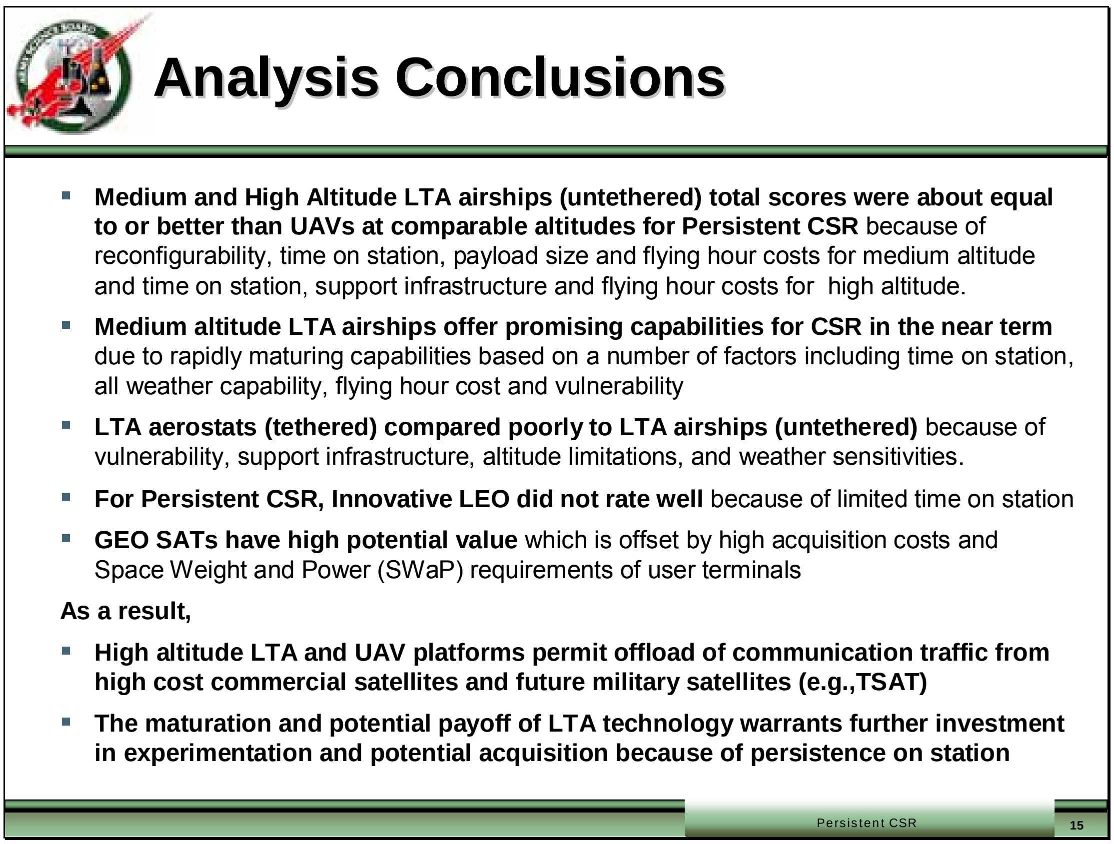
As noted in the observations, three platforms – medium altitude UAVs and untethered LTAs medium and high altitudes – are rated the highest in both charts. High altitude UAV platforms alternate with geosynchronous satellites for the fourth position. Geosynchronous satellites are very competitive for communication, but less so for surveillance and reconnaissance.

Altitude is more closely correlated with value than platform type, in that medium altitude UAVs correlate closer to medium altitude untethered LTA platforms than to high altitude UAV platforms. The same is true for high altitude UAV and high altitude untethered LTAs.

Low earth orbit innovative platforms did not score well in either case. The principal issue was the perception that “time on station” or persistence was difficult to reconcile with concepts that seemed to value small, low-cost platforms in sparse constellations.

A key point is that these comparisons are relative and the lowest scoring assets are still valuable assets; however, they did not score as well as others. An example is that low altitude tethered aerostats have a very low score but are currently performing adequately in theater providing continuous video feeds when elevated.

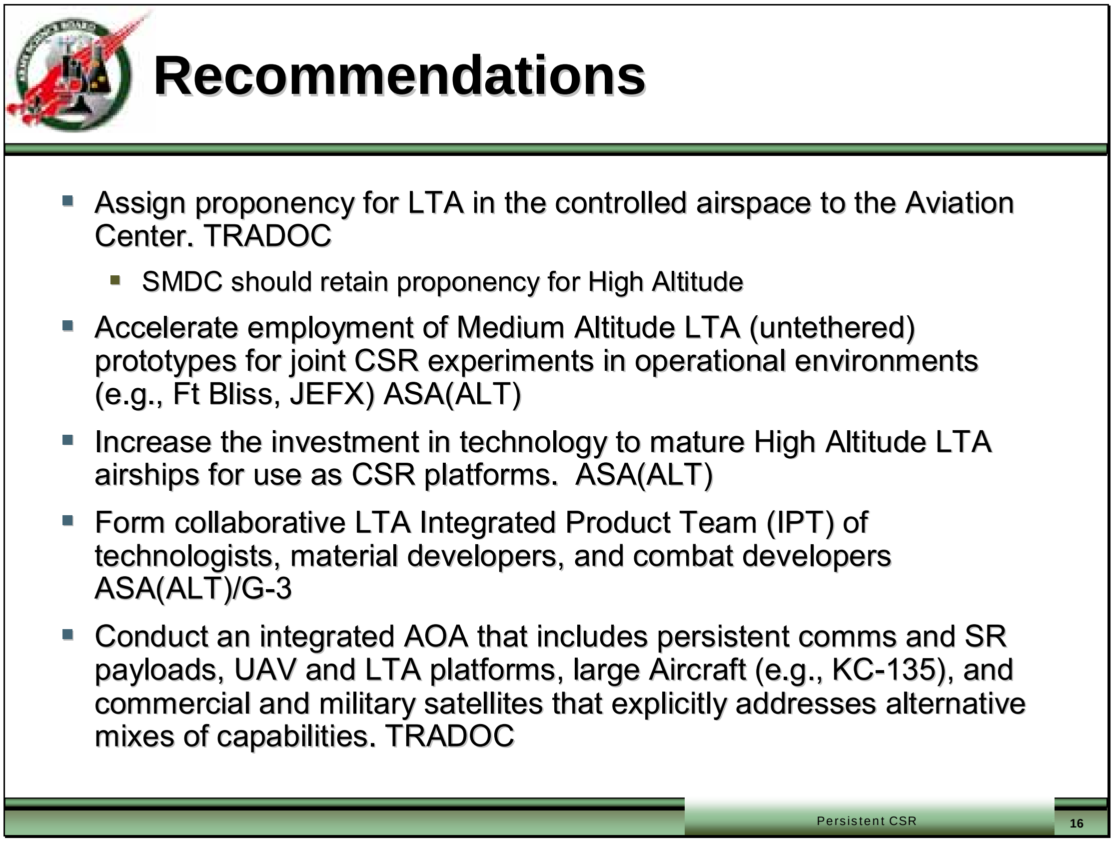
This analysis shows that higher altitude platforms provide greater area coverage and time on station leading to persistence.




Based on the analysis of both Comms and SR, conclusions are shown on the above chart. Medium and high altitude LTA airships showed great promise for increased mission support capability because of a number of key platform attributes. These include reconfigurability, time on station, payload size and flying hour costs. Additionally, the medium altitude LTA airship rapidly maturing technical capabilities also offer promise.

Tethered LTA aerostats have been used in current operational scenarios and have provided value, but are very vulnerable, have a large support structure, and suffer weather limitations. On the other hand, untethered LTAs offer great promise given the current scenario aspects.

Additionally, Innovative LEO did not rate well because of their very limited time on station. Further capability could be provided if used in a constellation arrangement.




Our recommendations are summarized on the above chart.

There is currently no proponent for Lighter Than Airships in the controlled air space - - this proponency should be assigned to the Aviation Center by TRADOC.

There is great value in continuing to examine the viability of LTAs in medium altitude operational scenarios - -therefore, accelerate LTA development and operational employment in experiments such as the FCS exercises at Ft Bliss and/or the annual JEFX.

The maturation of High Altitude LTA airships could also be hastened by increased investment - -   resources in this area need to be increased.

There also needs to be a collaborative organization that will enable the LTA community to support the continued development and fielding of LTA at low, medium and high altitude. Accordingly, it is recommended that a collaborative LTA IPT be formed including but not limited to AMCOM, AMRDEC, PEO Aviation, the Aviation Center, PEO Space and Missile Defense, and SMDC/ARSTRAT

Finally, the Army should conduct an integrated AOA that includes persistent Comms and SR payloads, UAV and LTA platforms, large Aircraft (e.g., KC-135), and commercial and military satellites that explicitly addresses alternative mixes of capabilities. Inputs from the LTA IPT should be available to assist in conducting the LTA aspects of the AoA.

# Bibliography Introduction

- The persistent CSR study team compiled a large number of references in the course of the study. These documents supported the analysis and provided ready reference to help answer questions and to learn more about systems and capabilities.
- The bibliography is organized in the same manner as the visits made by the CSR team. The visit schedule lists the trips. Following this "table of contents" is a detail of each visit, including the titles of the presentations provided to the CSR team during their visit. The electronic copy of the briefing can be found in the ASB CSR Knowledge Center, filed under the title of the trip or visit.
- Should you have any questions, please contact the ASB CSR Study Manager, Ms Anorme Anim.



# Bibliography

•SMDC/ARSTRAT – Redstone Arsenal - Dec 11 - 12

•Winter Plenary – Adelphi - Jan 11-12

  •G-6

•Co chairs meeting with Study Sponsor – Feb 22

• Ft Hood - March 17

  •1st CAV

  •CTSF

•JFCOM HQ – March 6

•Global Cyberspace Integration Center (GCIC) – Langley AFB – March 6

•TRADOC HQ – March 7

  •Ft Gordon

  •TRAC

  •Intel Center

•Kirtland AFB – Operationally Responsive Space (ORS) – March 17

•Intel Center - Ft Huachuca – April 14

•NGA – Bethesda – April 22

•NRO – Chantilly – April 22

•MITRE – April 23-24

  •DARPA

  •MITRE

  •SMDC

•CERDEC - Ft Monmouth – May 7

•NVESD - CECOM – May 8

•May Plenary – Houston - May 20 – 21

  •Lockheed Martin

  •Raytheon

•MITRE – McLean - June 24

  •SkySentry

  •Blackwater

  •SMDC/ARSTRAT

  •AMCOM

•Boeing – SoSIL – July 16

•Other Documents

# SMDC/ARSTRAT – Redstone

- SMDC COMMAND BRIEFING – Concept to Combat
- Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS)
- Operationally Responsive Space (ORS)
- Unmanned Aircraft Systems
- Future Army Space Capabilities Brief
- Wideband Global SATCOM (WGS) Features and Operations
- OVERWATCH Weapon Fire Detection and Location Capability
- *High Altitude*
- *Long Endurance Unmanned Aerial System (Zephyr HALE UAS)*
- *Army Space Power 2015*
- *Army Space Power 2035 Combined*
- *Future Capability Forecast*



# Winter Plenary – Adelphi

- G-6
  - Persistent Communications, Surveillance, and Reconnaissance (U)
- SMDC/ARSTRAT
  - Army High Altitude Information Briefing and Way Ahead

# Co chairs mtg with Study Sponsor

- Would like to have study look at HAA and HA alternatives—would like a capabilities based assessment—also look at how the same capability supports the different phases of a campaign—initial conflict , sustained combat, occupation, transition, civilian control—Giggle factor of HAA is something that must be overcome—TRADOC capabilities briefers still have a big giggle factor
- Look at the gaps that exist in the communications, surveillance, and reconnaissance, capabilities at different altitudes and what can be the GAP FILLERS—look at the different Service aspects of each of these 3 elements—look at near term things (3-5 years) and earlier
- Concerned that if TSAT doesn't happen, or is delayed, what are the alternatives (e.g. especially to support FCS)



# Ft Hood

- $1^{st}$ CAV
  - OIF 06-08 Overview
  - Lessons Learned
    - Communications
    - Surveillance
    - Reconnaissance
- CTSF
  - University XXI Brief & CR 3
  - TD Brief

# JFCOM HQ – Ft. Monroe

- Joint Transformation Command Intelligence briefings in HQ CCR
- C4 Systems Global Broadcast Services (GBS) briefing in HQ CCR
- JC2 Vision and the Commander's intent
- Airspace Employment and Policy
- Current Theater Efforts



# Global Cyberspace Integration Center (GCIC) – Langley AFB

- GCIC Mission
- Airborne Networking
- JEFX history/plans/projects

# TRADOC HQ

- HQ
  - Task Force Odin
- Ft. Gordon
  - Aerial Layer Network Transport (ALNT) ICD
- TRAC
  - Aerial Sensors & Relays (ASR) CBA
  - Unmanned Aerial Systems (UAS) Mix Analysis
- Ft. Huachuca - Intel Center
  - Tactical Persistent Surveillance White Paper



# Operationally Responsive Space - Kirtland AFB

- ORS Office Update

# Intel Center – Ft Huachuca

- Tactical Persistent Surveillance
- EW/CNO Overview; Proposed Sensor Study Objectives and Fusion
- WICA Discussions
- ISR Experiment



# NGA - Chantilly

- Army Geospatial Governance Board (GGB)
- Ops Intel
- JPSIO and Evolving TTP for Persistent Surveillance
- NGA Space Utilization Study – TX
- Developmental GEOINT technologies applicable for enhanced support to land warfare operations – OMW

# NGO - Bethesda

- “Overwatch” Dissemination
- DCGS-IC
- Emitter Imaging
- Unique Technical Applications
- Msn Support Maneuver Unit:IED Alert
- Msn Support Maneuver Unit: WAVERUNNER
- Army Geospatial Governance Board (GGB)



# MITRE – McLean

- DARPA
  - ORCA
  - A160 Helicopter UAV
  - ISIS
  - TIGRnet
  - VULTURE UAV
  - Heterogeneous Unmanned Reconnaissance Team (HURT)
- MITRE
  - Landscape of Current UAVs in OIF
- SMDC
  - WGS Overview
  - Space-based Persistence for the Tactical Warfighter
  - Low Altitude Elevated CSR
- TRADOC HQ
  - Metrics

# CERDEC – Ft Monmouth

- PM WIN-T
- Command and Control Robotic Entities (C2ORE)
- Intelligence Dissemination
- MR-TCDL
- RF Tags SAR/GMTI
- Army DCGS-A
- C4ISR OTM Airborne Tier Activities
- HARC
- BTCR
- Antennas
- Modeling and Simulation



# NVESD - CECOM

- Warfooting Support
- Night Eagle **(Classified)**
- Constant Hawk Night
- Airborne Unmanned Persistent Imaging
- IED and Minefield Detection Payload for Shadow TUAV
- Tactical Airborne Persistent Surveillance

# May Plenary - Houston

- Lockheed Martin
  - Persistent Elevated Reconnaissance, Surveillance, and Intelligence Unmanned System (PERSIUS) JCTD
  - Integrated Sensor Is System (ISIS)
  - High Altitude Airship (HAA)
  - Persistent Threat Detection System (PTDS)
  - Video from UAS for Interoperability Teaming Level 2 (VUIT-2)
- Raytheon
  - Persistent Communications Surveillance and Reconnaissance Study



# MITRE – McLean

- SMDC
  - *High Altitude Long Loiter (HALL) Efforts*
  - *SMDC ONE Update*
- AMCOM
  - Lighter Than Air Systems For Persistent Operations
- ASB
  - CSR Analytical Model
- SkySentry
  - High Altitude Long Endurance (HALE) Vehicle Development Program
- Blackwater
  - Unmanned Aircraft System: Polar 400 Remotely Piloted Airship Vehicle

# SoSIL - SoSIL

- **FCS Update – Acceleration**
- **SoSIL Overview and Tour**
  - **Packbot**
  - **Integrated Computer Systems Lab**
  - **Network Communication Lab**
  - **JTRS Brief**
  - **SW Integration Lab**
  - **SOSCOE Factory**
  - **Spin Out B Kit Integration & Test Cell**
  - **Experiments and JEFX08**
  - **C2V Mock Up**
- **Information Dissemination through the Network Using SOSCOE**



# Other Documents

- AFSAB Near Space Report
- AFSAB Report on OUOSS
- ALNT ICD Draft V16
- Automation Dependencies vs Airspace Data
- Bfg Airships Comparisons
- Cable Systems Trades – mETRICS
- Defense Systems Article on High Bandwidth
- Earth Observer UAV – Vol 1 V1
- Executive Summary – ALLFIND JT&E
- Global Observer Overview Brief
- GO JCTD ID
- GO JCTD JACL Review
- GO-01-AV-GO-SkyTower-Web
- Harris JPL Comms Relay
- Harris UAV Trades
- HNW Overview
- Mode 5 and Objective COP
- MUOS 101 Army Science Board
- NASA-2007-HALE UAV AoA
- NRAC Lighter Than Air Report
- Short Term Air Pix Improvements
- Tethered Aerostats
- Tethered Aerostats Navy
- Virtual See and Void2

# APPENDIX A

# TERMS OF REFERENCE

**DEPARTMENT OF THE ARMY**
**WASHINGTON DC 20310-0103**

MAR 2 8 2008

Dr. Frank H. Akers, Jr.
Chairman, Army Science Board
2511 Jefferson Davis Highway
Arlington, Virginia 22202

Dear Dr. Akers:

I request that the Army Science Board (ASB) conduct a study entitled "Persistent Communications, Surveillance and Reconnaissance (CSR) for the Current and Future Force." The study should be guided by, but not necessarily limited by, the Terms of Reference described below:

Background: Current studies of the military operations in Operation Enduring Freedom and Operation Iraqi Freedom, as well as predictions concerning similar future operations indicate a need for better (increased or more efficient) communications coverage as well as enhanced sensor capability for reconnaissance and surveillance. "Better" and "enhanced" can assume a broad range of meanings depending on the situation and echelon involved; however, it is generally accepted that one goal relates to persistence of communication and sensing; another relates to clarity or fidelity, and a third relates to available bandwidth. In three previous ASB studies, two involving Intel and one involving LandWarNet, persistent contact among all echelons has been suggested and persistent overwatch and surveillance has been sought. These improvements are especially necessary in order to maintain situational awareness and reachback for supporting fires as well as providing knowledge of location and condition of friendly and enemy units. Further, information requirements of forces (whether large or small) in imminent contact with enemy forces demand nearly continuous and timely information flow, better ensuring the safety of forces and increasing the margin of victory.

Expanding situational awareness and facilitating communications among units allows all types of modular brigades to enjoy greater mobility, especially if communications can be maintained while "on-the-move" and in austere environments. Such capability will also improve reachback for support from non-organic fires and intelligence.

Scope: Obtaining the best balance between performance, mobility, and supportability of communications and sensing capabilities is critical to enhancing the effectiveness of combat units at every level of command. Thus, organizing appropriate combinations of communications equipment and sensors is a focal point of this study in support of the operational concepts for the current and future forces. In some cases, combinations of highly elevated platforms are most effective in providing necessary capabilities. In other cases, ground based sensors might be the most useful. In any event, a systematic approach to developing a model for communications and sensing using combinations of available assets is necessary to utilize those assets in the most efficient fashion.

The goal of this study is to suggest a concept and structure for best use of CSR assets, including reporting on:

a. What technical capabilities are possible from Space-based, "Near-Space" based, High-Altitude Long-Endurance Unmanned Aerial Vehicle (UAV)-based or Airship-based platforms?

b. How do these capabilities compare to those available on lower altitude UAVs as well as ground-based and other assets?

c. How does one trade off the benefits and weaknesses of each type of asset?

d. To what degree can both the current and the future forces increase mobility and sustainability through integration and systematic use of such assets?

e. To what degree do such platforms decrease the logistics and support burden for sustained operations?

f. How does cost of each type of platform compare?

Study Sponsorship: Sponsor for this study is the United States Army Space and Missile Defense Command/Army Forces Strategic Command.

Study Duration: A briefing will be provided by July 24, 2008. The final report should be provided by October 15, 2008.

Sincerely,

Dean G. Popps
Acting Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

# APPENDIX B

# PARTICIPANTS LIST

# Persistent CSR Study Membership

**CO-CHAIRS**

**LTG(Ret) William Campbell** **Mr. Chuck Vehlow** **Dr. Mike Wartell**

**STUDY TEAMS**

Senior Government Advisor –
Mr. Tom Pagán

Study Manager
Ms. Anorme Anim – ASB

**Communications (Comms) Team**

Dr. Allen Adler

Dr. Pete Swan

BG(Ret) Bob Wynn

Ms. Madhu Beriwal

**Surveillance & Reconnaissance (SR) Team**

Dr. Darrell Collier

Mr. Herb Gallagher

Mr. Gary Glaser

Mr. Steve Scalera

ROTC Cadet – Ms. Jolene Puthoff

# APPENDIX C

# ACRONYMS

| | |
|---|---|
| AFB | Air Force Base |
| AHP | Analytic Hierarchy Process |
| AMCOM | Aviation and Missile Command |
| AMRDEC | Aviation and Missile Research Development and Engineering Center |
| AoA | Analysis of Alternatives |
| ASA(ALT) | Assistant Secretary of the Army for Acquisition, Logistics and Technology |
| ASB | Army Science Board |
| ATO | Air Tasking Orders |
| BCT | Brigade Combat Team |
| BLOS | Beyond-Line-of-Sight |
| CAV | Cavalry |
| CSR | Communications, Surveillance and Reconnaissance |
| DARPA | Defense Advanced Research Projects Agency |
| DSCS | Defense Satellite Communications System |
| GEO | Geosynchronous Earth Orbit |
| GPS | Global Positioning System |
| HQ | Headquarters |
| IPT | |
| JEFX | Joint Expeditionary Force Experiment |
| JFCOM | Joint Forces Command |
| JLENS | Aerostat with radars; Joint Land Attack Cruise Missile Defense Elevated Netted Sensor |
| JUONS | Joint Urgent Operational Needs Statements |
| LEO | Low Earth Orbit |
| LTA | Lighter than Air |
| LTG | Lieutenant General |
| MANPAD | Man Portable Air Defense |
| MEO | Medium Earth Orbit |
| MITRE | A Federally Funded Research and Development Center (FFRDC); originally "Massachusetts Institute of Technology Research and Engineering" |
| NGA | National Geospatial Intelligence Agency |
| NRO | National Reconnaissance Office |
| NVL | Night Vision Laboratory |
| OEF | Operation Enduring Freedom |
| OIF | Operation Iraqi Freedom |
| ORS | Operationally Responsive Space |
| PEO | Program Executive Office |
| PM | Program Manager |
| RAID | Rapid Aerostat Initial Deployment |
| RAID | Rapid Aerostat Initial Deployment |
| ROTC | Reserve Officer Training Corps |
| SAT | Satellite |
| SMDC/ ARSTRAT | Space and Missile Defense Command / Army Forces Strategic Command |

| | |
|---|---|
| SR | Surveillance and Reconnaissance |
| SWaP | Size, Weight and Power |
| TOR | Terms of Reference |
| TRAC | TRADOC Analysis Center |
| TRADOC | Training and Doctrine Command |
| TRL | Technology Readiness Level |
| UAS | Unmanned Aerial System |
| UAV | Unmanned Aerial Vehicle |
| UFO | UHF Follow-on |
| VFR | Visual Flight Rules |