LANCE MENTHE, DAHLIA ANNE GOLDFELD, ABBIE TINGSTAD, SHERRILL LINGEL, EDWARD GEIST, DONALD BRUNK, AMANDA WICKER, SARAH SOLIMAN, BALYS GINTAUTAS, ANNE STICKELLS, AMADO CORDOVA

Technology Innovation and the Future of Air Force Intelligence Analysis

Volume 1, Findings and Recommendations

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Preface

The Air Force Distributed Common Ground System (AF DCGS) is responsible for producing and distributing actionable intelligence from data collected by a wide variety of U.S. Air Force platforms for warfighters around the world. Over the past two decades, intelligence collections and demand for intelligence products have grown exponentially, straining analytic capacity. At the same time, intelligence analysts are often too busy performing routine processing, exploitation, and dissemination (PED) tasks to focus on larger strategic analyses that may be required to meet future threats envisioned by the 2018 National Defense Strategy. A 2012 RAND Project AIR FORCE (PAF) report suggested that artificial intelligence (AI) would one day be able to help free analysts to do tasks that make better use of human intelligence. Since that report was published, AI and machine learning (ML) have made enormous advances, and we foresee further innovation in the coming years.

In 2017, Air Force/A2 asked PAF to analyze how current and potential future technologies could help AF DCGS be more effective, efficient, adept at using human capital, and agile. We were also asked to consider the process, training, and organizational improvements needed to make the best use of these technologies. The research project, *Closing the PED Gap*, was conducted in fiscal year 2018 in PAF's Force Modernization and Employment Program. The research is discussed in three companion reports:

- *Technology Innovation and the Future of Air Force Intelligence Analysis:* Volume 1, *Findings and Recommendations*, RR-A341-1, 2021 (this report). Volume 1 provides essential findings and recommendations for a broad audience, including Air Force decisionmakers.
- *Technology Innovation and the Future of Air Force Intelligence Analysis:* Volume 2, *Technical Analysis and Supporting Material*, RR-A341-2, 2021. Volume 2 provides more in-depth discussion of project methodology; a primer on AI and ML; more-detailed discussion of key recommendations; and other information of interest to specialists, stakeholders, and experts.
- *Technology Innovation and the Future of Air Force Intelligence Analysis:* Volume 3, *Technical Assessment of Data Flow Maps*, forthcoming, Not available to the general public. Volume 3 furnishes additional restricted detail.

This report should be of interest to policymakers within the Air Force and the wider intelligence community.

The research reported here was commissioned by U.S. Air Force/A2 and conducted within the Force Modernization and Employment Program of PAF as part of a fiscal year 2018 project *Closing the PED Gap*.

RAND Project AIR FORCE

RAND Project AIR FORCE (PAF), a division of the RAND Corporation, is the Department of the Air Force's (DAF's) federally funded research and development center for studies and analyses. PAF provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat readiness, and support of current and future air, space, and cyber forces. Research is conducted in four programs: Strategy and Doctrine; Force Modernization and Employment; Manpower, Personnel, and Training; and Resource Management. The research reported here was prepared under contract FA7014-16-D-1000.

Additional information about PAF is available on our website:

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This report documents work originally shared with the Department of the Air Force on October 3, 2018. The draft report, issued on September 26, 2018, was reviewed by formal peer reviewers and DAF subject-matter experts.

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Summary

Issue

There is growing demand for the Air Force Distributed Common Ground System (AF DCGS) to analyze sensor data. Getting the right intelligence to the right people at the right time is increasingly difficult as the amount of data grows and timelines shrink. The need to exploit all collections limits the ability of analysts to address higher-level intelligence problems. Current tools and databases do not facilitate access to needed information.

Approach

Air Force/A2 asked RAND Project AIR FORCE (PAF) to analyze how new tools and technologies can help meet these demands, including how artificial intelligence (AI) and machine learning (ML) can be integrated into the analysis process. PAF assessed AF DCGS tools and processes, surveyed the state of the art in AI/ML methods, and examined best practices to encourage innovation and to incorporate new tools.

Conclusions

- Many analytic tasks can be fully or partially automated, although human involvement will continue to be necessary in more-complex tasks.
- AI/ML can free analysts to focus on solving intelligence problems and developing supporting technologies to make analysis more efficient.
- Analysts will require new skills both to facilitate use of AI/ML and to take advantage of opportunities to conduct more-advanced analysis.

Recommendations

AF DCGS should

- leverage existing technologies to automate some analysis and reporting tasks and to make archival intelligence more accessible
- take advantage of AI/ML technologies, when available, for early-phase analysis tasks (e.g., identifying and tagging imagery, issuing threat warnings, re-tasking collectors)
- organize to balance human effort across three competencies: supporting missions, supporting analysis, and solving intelligence problems
- recruit and train analysts with data science, programming, and other skills
- follow best practices for developing, implementing, and sustaining new tools.

Figure S.1. Major Recommendations

	IMPROVEMENTS USING TODAY'S TECHNOLOGY
GEOINT	Create a GEOINT Analysis and Reporting Tool to semi-automate product generation and mission reporting & assessment for EO/IR/SAR, FMV, MTI
GEOINT	Create Linker tool to tie information used to confirm the exploitation back to the source
GEOINT	Create improved Formatter for threat warning
GEOINT	Create Updater script to automatically re-issue updated MTI threat warning messages
GEOINT	Adopt Graphic Information System (GIS) into the MTI workflow and write Python scripts to automate GIS analysis processes
GEOINT	Assess risks and benefits of adopting the industry standard in video editing tools (Avid)
SIGINT	Create Scraper script to add warnings to reports
SIGINT	Build scripts and adjust workflow to transform or eliminate Technical Reporter position
SIGINT	Address barriers to using IC networks to pave the way for leveraging future capabilities
Multi-INT	Reengineer and accelerate OA DCGS rollout
Multi-INT	Build on current efforts to link Crew Manning Letters, PED Tasking Orders, personnel qualifications databases, shift scheduling

	AI/ML-ENABLED IMPROVEMENTS
GEOINT	Use AI/ML to perform partial first phase analysis (e.g. tag imagery, identify objects and people)
GEOINT	Use AI/ML to alert human analysts of significant changes in activity
GEOINT	Use AI/ML to generate threat warnings with human-on-the loop
GEOINT	Use AI/ML to dynamically retask collectors
GEOINT	Use AI/ML to analyze archived FMV imagery
GEOINT	Seek to lift the "eyes on" requirement for FMV missions where the "ISR role" indicates no risk of troops in contact or strike decisions, and when AI/ML tools can alert human analysts to other events that require real-time judgment
SIGINT	Leverage IC capabilities while maintaining organic capabilities for threat warning
Multi-INT	Leverage IC capabilities for fusion and analysis
Multi-INT	Make cloud computing the centerpiece of the next hardware refresh

	NON-MATERIEL IMPROVEMENTS
Skills	Teach GIS basics at Goodfellow AFB
Skills	Encourage certificates for data science and programming, consider expanding Combat Readiness Sustainment Program, use time while analysts wait for clearances to expand skills and certifications
Skills	Retain basic INT skills for some Airmen, even where they may appear obsolete because of AI/ML
Skills	Support and expand rehearsal-of-concept drills
Skills	Hold an annual WEPTAC conference for sharing best practices among AF DCGS sites, particularly the DCGS Analysis and Reporting Team
Skills	Encourage use of mission type orders and focused collection operations
Innovation	Emphasize user engagement at each stage; involve DGS-3 early in the development process of new tools
Innovation	Identify opinion leaders and champions at DGS sites to foster tool development
Innovation	Reward innovators with time to sustain their own innovations and to build new things
Innovation	Create a process for gracefully offboarding old tools

GEOINT=geospatial intelligence
SIGINT=signals intelligence
EO=electro-optical
IR=infrared
SAR=synthetic aperture radar
FMV=full motion video
MTI=moving target indicator
OA=open architecture
IC=intelligence community
WEPTAC=weapons and tactics
DGS=Distributed Ground Station

NOTE: We recommend near-term improvements that can be implemented today and farther-term improvements that require technical breakthroughs or significant adjustments to AF DCGS network architecture and non-materiel improvements to make the AF DCGS more scalable while maintaining core capabilities. More detail on implementation is provided in Menthe et al., 2021, and Menthe et al., forthcoming. The latter includes more-extensive discussion of SIGINT.

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There are far too many people for us to thank, including many who shared their insights with us in confidence. The efforts of all these people made this report possible.

Abbreviations

AF DCGS	Air Force Distributed Common Ground System
AI	artificial intelligence
CCMD	combatant command
COTS	commercial off-the-shelf
CRSP	Combat Readiness Sustainment Program
DART	Distributed Common Ground System Analysis and Reporting Team
DCGS	Distributed Common Ground System
DGS	Distributed Ground Station
EEI	essential elements of information
FMV	full motion video
GEOART	geospatial intelligence analysis and reporting tool
GEOINT	geospatial intelligence
GIS	geographic information system
IC	intelligence community
INT	intelligence
ISR	intelligence, surveillance, and reconnaissance
JWICS	Joint Worldwide Intelligence Communications System
ML	machine learning
MTI	moving target indicator
MTO	mission type order
OA	open architecture
OSINT	open-source intelligence
PED	processing, exploitation, and dissemination
RoC	rehearsal of concept
SIAS	sense, identify, attribute, and share
SIGINT	signals intelligence

TR	technical reporter
TRL	technology readiness level
WAMI	wide-area motion imagery
WEPTAC	weapons and tactics

1. Technology Innovation and the Future of Air Force Intelligence Analysis: Findings and Recommendations

Introduction

The Air Force Distributed Common Ground System (AF DCGS) is the global intelligence, surveillance, and reconnaissance (ISR) weapons system responsible for producing and distributing actionable intelligence from sensor data collected by the MQ-1 Predator,[1] MQ-9 Reaper, U-2S, RQ-4 Global Hawk, and other Air Force platforms. The AF DCGS must also provide urgent threat warnings for those aircraft and other elements in the vicinity based on that intelligence. This critical analytic enterprise involves thousands of active-duty Air National Guard, Air Force Reserve, coalition partner personnel (working in more than two dozen locations worldwide), and extensive contractor support.[2] The AF DCGS has proven to be a vital resource for joint and coalition operations, especially during the high tempo of counterinsurgency, counterterrorism, and humanitarian and disaster relief operations seen in recent years.

But the AF DCGS has also been a victim of its own success. As sensors become better and more ubiquitous, the amount of data they produce escalates.[3] Warfighters are also demanding more near-real-time intelligence to support ongoing operations. At the same time, the intelligence questions are becoming more sophisticated. Some examples of the complexity of the intelligence questions include the following: What additional moves, if any, is China making to militarize the South China Sea? What terrorist networks may still persist and present threats in Iraq and Syria? Are the Russians directly supporting insurgent operations in Ukraine? To answer such questions, analysts must be able to access and synthesize many different types of intelligence collected over longer timescales and different geographical areas. The challenge of these tasks is exacerbated by the need to get the right intelligence to the right people at the right time. Analysts must summarize, sort, store, and send ever-larger amounts of data on increasingly shorter timelines. All these issues will become more acute as the United States shifts its strategic

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[1] The Air Force officially retired the MQ-1 Predator on March 9, 2018, but sensor data collected by these platforms remain in the system. See Stephen Losey, "Air Force Announces Official Retirement Date for Iconic MQ-1 Predator Drone," *Air Force Times*, February 16, 2018.

[2] U.S. Air Force, "Air Force Distributed Common Ground System," webpage, October 13, 2015. For a detailed discussion of AF DCGS organization, roles, processes, and competencies, see Chapter 2 of Volume 2 (Lance Menthe, Dahlia Anne Goldfeld, Abbie Tingstad, Sherrill Lingel, Edward Geist, Donald Brunk, Amanda Wicker, Sarah Soliman, Balys Gintautas, Anne Stickells, and Amado Cordova, *Technology Innovation and the Future of Air Force Intelligence Analysis*: Volume 2, *Technical Analysis and Supporting Material*, Santa Monica, Calif.: RAND Corporation, RR-A341-2, 2021).

[3] Chapter 2 of Volume 2 (Menthe et al., 2021) discusses the exponential growth of sensor data.

focus from the less capable (although still formidable) adversaries encountered in recent years to the highly capable peer competitors envisioned by the National Defense Strategy.[4]

In 2017, Air Force/A2 asked RAND Project AIR FORCE (PAF) to examine how tools and technologies, including artificial intelligence (AI) and machine learning (ML) methods, available today or in the foreseeable future could help the AF DCGS evolve to meet the above challenges. Although previous PAF research forecasted that AI/ML could one day play a role in the AF DCGS,[5] the state of the art has accelerated to the point where we can now see with greater specificity *how* AI/ML might be used and can lay out a roadmap for incorporating technologies as they become available. The recommendations in this report provide a path to evolve the traditional "processing, exploitation, and dissemination (PED)"[6] approach and move toward the "sense, identify, attribute, share (SIAS)" paradigm adopted in the recent ISR flight plan.[7] Unlike traditional, stovepiped models of analysis that are designed to answer basic intelligence questions from airborne collectors, SIAS emphasizes fusing data from all sources to answer more-advanced intelligence questions and distribute that information widely.[8]

This report (Volume 1 of three) summarizes the major findings and recommendations from our analysis. We first review the challenges that AF DCGS encounters today and the objectives for improvement. We then provide a brief overview of how AI/ML technologies could play a role in addressing those challenges. Finally, we recommend a way forward for the AF DCGS in three areas: (1) making the most of technology available today, (2) taking advantage of future technology as it becomes available, and (3) addressing the human factors—organization, training, and culture—that are critical to success. A recurrent theme in this research is that AI/ML does not simply perform certain analytic tasks better and faster than humans; it can free analysts to focus on the higher-level intelligence problems for which humans are uniquely suited—and that are increasingly demanded by warfighters. AI/ML is but one part of the larger evolution that AF DCGS can and should make.

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[4] U.S. Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*, Washington, D.C., 2018.

[5] Lance Menthe, Amado Cordova, Carl Rhodes, Rachel Costello, and Jeffrey Sullivan, *The Future of Air Force Motion Imagery Exploitation: Lessons from the Commercial World*, Santa Monica, Calif.: RAND Corporation, TR-1133-AF, 2012. See Chapter 1 of Volume 2 (Menthe et al., 2021) for an overview of prior PAF analyses.

[6] The terminology and abbreviations used to describe these activities have varied over time. Chapter 1 of Volume 2 (Menthe et al., 2021) discusses other terms.

[7] U.S. Air Force, *Next Generation ISR Dominance Flight Plan: 2018–2028*, Washington, D.C.: Congressional Research Service, R46389, July 24, 2018.

[8] John A. Tirpak, "'PED Is Dead': ISR Roadmap Reaches Long for New Tech," *Air Force Magazine*, August 2, 2018.

Volume 2 provides more-detailed information on all the topics covered here, including a primer on AI/ML technologies of interest to AF DCGS analysts.[9] Volume 3 provides further restricted detail.

Current Air Force Distributed Common Ground System Challenges

To understand how AI/ML and other automating technologies could play a role in helping AF DCGS manage the ever-increasing supply of data—and demand for timely intelligence on more-challenging problems—we must first understand the obstacles and challenges within the current enterprise. A major issue is that basic analysis of incoming collections currently requires enormous human effort, often at the expense of doing higher-level synthesis of information from many sources to answer larger intelligence questions. The generic data-flow map in Figure 1.1 illustrates the tasks that analysts on the operations floor typically perform for incoming collections. The process begins at the top with data collection and moves through processing and exploitation to dissemination and storage. The shaded areas indicate the roles that analysts play throughout the process. We group AF DCGS positions into four main roles: *exploiters* who perform first-phase analysis of ingested data and answer fundamental questions about specific collections; *investigators* who pursue intelligence questions, fuse information, and conduct deeper levels of synthesis; *reporters* who prepare and store intelligence products and warning messages; and *supervisors* who oversee missions and personnel, clarify tasks, perform quality control, and conduct assessments.[10] A key point is that most of the steps in this process currently involve direct, intensive involvement by analysts who must review the collections; decide on their utility; potentially re-task collectors; assess threats; actively search for relevant contextual information from various sources; and compose, format, transmit, and store various products tailored for different parties. The sheer volume of supply (i.e., information collected) and demand (i.e., analysis support to warfighters, often on short timelines) poses an enormous challenge for AF DCGS crews as they are currently sized and organized.

In addition, previous PAF work shows that the continual oscillation between tedious, mind-numbing periods (e.g., watching video in which nothing is happening) and frantic, high-tempo

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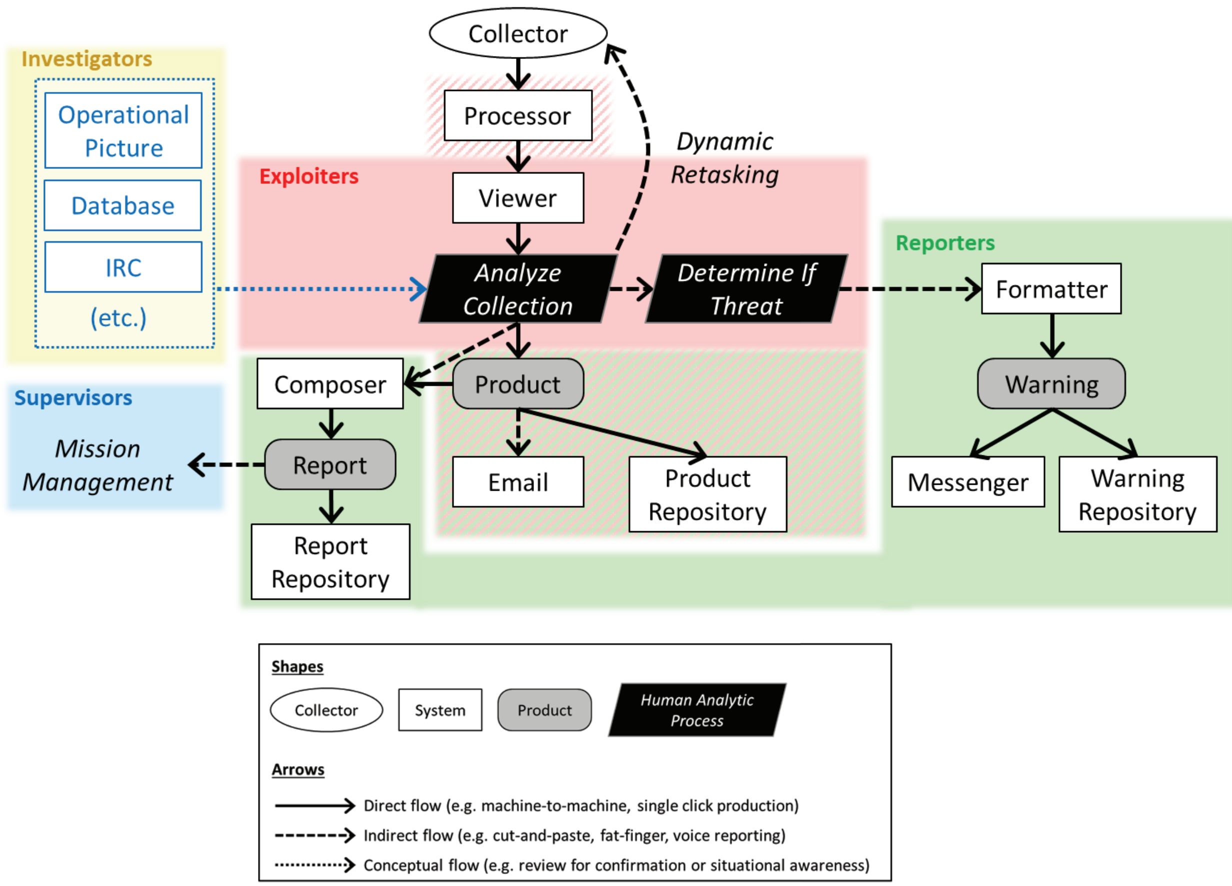
[9] Volume 2 (Menthe et al., 2021) also discusses the methodology, scope, and key terms used in the research; describes the current AF DCGS organization, roles, and processes; and reviews case studies that illustrate enduring challenges for intelligence analysis. Further restricted detail is provided in Volume 3 (Menthe et al., forthcoming).

[10] Chapter 2 of Volume 2 (Menthe et al., 2021) describes the roles and the positions. This approach allows us to focus on the crew workflow, independent of analyst positions. Note that the division of roles in Figure 1.1 is approximate and sometimes overlaps. For example, depending on the sensor, processing may occur onboard the aircraft or at the AF DCGS itself; consequently, we crosshatch this system to indicate that it is only sometimes part of the exploiter responsibility. Similarly, we crosshatch part of the product generation and reporting process to indicate that it may be performed by exploiters or reporters, depending on the intelligence (INT).

periods where warfighters' lives are on the line takes a psychological toll on analysts and can contribute to burnout and lower retention.[11]

Figure 1.1. Generic Data-Flow Map (Current Process)



NOTE: The blue-outlined boxes (yellow background) in the upper left corner are optional and vary with specific circumstances. IRC = internet relay chat.

Additional process and system issues can make the activities outlined in Figure 1.1 even more challenging. Many analysts we spoke with pointed to three major impediments:

- **Need to move between many systems.** Analysts spend substantial time working with a wide variety of systems that are sometimes only semi-compatible. This is an artifact of the operational surges in Iraq, Afghanistan, and elsewhere, during which the AF DCGS had to rapidly conceive, acquire, and connect systems, tools, and databases to meet immediate warfighter needs. However, analysts are less efficient and require more training than if they used a smaller number of compatible systems.

[11] Lance Menthe, Amado Cordova, Elliot Axelband, Lindsay D. Millard, Abbie Tingstad, Endy Daehner, Kirsten M. Keller, and John Langley, *Technologies and Processes for Automating Processing, Exploitation, and Dissemination,* Santa Monica, Calif.: RAND Corporation, 2015, Not available to the general public.

- **Difficulty navigating classification boundaries.** Analysts must understand and work within the various classification levels and dissemination caveats associated with different systems, data, and products. Some analysts report difficulty in locating the correct guidance, which takes time away from analysis. Lack of clarity and standardization to move appropriate information through various classification boundaries can also make the AF DCGS less agile in supporting allies and partners.[12]
- **Burdensome reporting requirements.** Figure 1.1 shows that a large portion of analysts' work involves preparing and disseminating products.[13] These products come in dozens of varieties and involve many different protocols designed to maintain compatibility with legacy systems and to maintain security. Analysts can spend an inordinate amount of time reviewing and implementing protocols. We observed this issue most strikingly in SIGINT. More than one PED crew member in a reporter role offered that, with the right tools, their position could be fully automated today. One said that their "entire job" was to take one kind of "carefully formatted report" and "hand-jam" it elsewhere to create a different kind of carefully formatted report. This task was needed in part because the systems involved were not fully compatible, and the necessary scripts that might bridge them did not exist. If airmen's current reporting role could be streamlined, those airmen believed they could shift their focus to creating higher-quality products, particularly for threat warning.

The difficulties of keeping up with supply and demand will only increase as sensors and collection platforms continue to improve and proliferate and as warfighters potentially face more-challenging and novel threat environments.

At the same time, constantly trying to conduct PED for each platform and collection prevents analysts from working on higher-level problems that require fusion of many different intelligence sources collected over longer periods. The AF DCGS took an important step toward addressing this problem by creating DCGS Analysis and Report Teams (DARTs) in 2007. These teams are specifically tasked with doing this kind of higher-level synthesis (among other tasks). However, even when analysts have time to work on broader intelligence problems, they cannot easily access the massive amounts of data they require. Data are currently stored in different formats on many different systems—not just within the AF DCGS, but across the intelligence community (IC). Many analysts we spoke with said that they have difficulty accessing recent and historical information that might be relevant to a specific geographic area, target, electromagnetic frequency band, or other factor that can help contextualize what they are examining. We observe that there often appears to be relevant information *somewhere*, if only the analyst can find it. Rapidly accessing information from multiple types of intelligence (*multi-INT*) can be hindered by policy and technological issues alike. One of the key differences between a more-experienced analyst and a less-experienced analyst is simply knowing where to

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[12] Chapter 3 of Volume 2 (Menthe et al., 2021) examines the impact of this issue on humanitarian and disaster relief operations.

[13] Some products are more time-intensive or time-sensitive than others, and the challenges are not the same for all types of intelligence.

find the information. Better data-management systems and tools would help analysts overcome these barriers.

Objectives for Improving the Air Force Distributed Common Ground System

The supply of collections data and the demand for intelligence analysis are not within the AF DCGS's power to change; the enterprise itself must evolve to meet the challenges they pose. There are essentially four areas in which the AF DCGS can seek to improve: becoming more *efficient*, becoming more *effective*, making better use of *human capital*, and becoming more *agile*. Any change in AF DCGS process, organization, or tools (including use of AI/ML) should help address at least one of these objectives.

- **Be more efficient.** Improving efficiency means doing essentially what the AF DCGS does today, only doing more of it, doing it faster, or doing it by expending fewer resources. Efficiency is most commonly measured in terms of time, person-hours, cost, and throughput. These are standard process metrics. By *time*, we mean how long data dwell in the AF DCGS from the moment raw data enter to when the products are disseminated.
- **Be more effective.** Improving effectiveness means doing better or more in-depth analysis. These are *product* metrics. In general terms, an intelligence product may be considered "better" if it is more accurate, more complete, or more useful (a more timely product is also desirable, but we consider that to be an aspect of efficiency). For example, for a motion imagery processing and exploitation algorithm, appropriate metrics might be the percentage of objects correctly detected and identified or the probability of false identification.[14] A product might also be more useful if it answers higher-priority intelligence questions or finds "unknown unknowns." Ideally, the value of an intelligence product would be measured by how it positively affects outcomes in the supported operations.[15]
- **Make better use of human capital.** Good use of human capital can improve efficiency and effectiveness of analytic processes,[16] but it can also mean increasing the value of having a human (vice a machine intelligence) involved in the process to some degree. Examples of metrics include a decrease in mundane task workload, more opportunities for career or skill development, and increased analyst job satisfaction. Various mental health metrics may also be useful proxies or provide insights.

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[14] Amado Cordova, Lindsay D. Millard, Lance Menthe, Robert A. Guffey, and Carl Rhodes, *Motion Imagery Processing and Exploitation (MIPE)*, Santa Monica, Calif.: RAND Corporation, RR-154-AF, 2013.

[15] As discussed elsewhere (Abbie Tingstad, Dahlia Anne Goldfeld, Lance Menthe, Robert A. Guffey, Zachary Haldeman, Krista S. Langeland, Amado Cordova, Elizabeth M. Waina, and Balys Gintautas, *Assessing the Value of Intelligence Collected by U.S. Air Force Airborne Intelligence, Surveillance, and Reconnaissance Platforms*, Santa Monica, Calif.: RAND Corporation, RR-2742-AF, forthcoming), assessing ISR effectiveness can present its own challenges.

[16] *Human capital* is defined in many ways. One useful definition that focuses on output is: "An amalgam of factors such as education, experience, training, intelligence, energy, work habits, trustworthiness, and initiative that affect the value of a worker's marginal product." See Robert H. Frank and Ben S. Bernanke, *Principles of Microeconomics*, 3rd ed., New York: McGrawHill/Irwin, 2007.

- **Be more agile.** Finally, agility is a broad set of criteria including both individual and organizational factors. Agility in this context is characterized by the ability to adapt and change quickly to analyze data from new types of sensors, adopt new analysis technology, operate in new areas or support different combatant commands (CCMDs), and support new types of missions. It also includes resiliency against disruption, such as the ability to shift full motion video (FMV) lines between Distributed Ground Station (DGS) sites to maintain full operations in the event of communications problems. Metrics for agility may capture the timeliness to integrate new tools or the amount of resources allocated for innovation and adaptive planning for alternative futures. Some improvements may not provide immediate benefits in terms of efficiency and effectiveness, but they may set the conditions for future success in these areas.

Although the objectives just outlined are not new for the AF DCGS,[17] the means of achieving them are ever evolving. The remainder of this report considers whether and how AI/ML can help address the AF DCGS's challenges today and in the near future by making the enterprise more efficient, effective, adept at using human capital, and agile.

The Promise of Artificial Intelligence/Machine Learning

AI/ML is a complex, ever-evolving field that includes many different techniques and potential applications.[18] AI/ML is an important set of methods, but not the only ones that are of interest to the AF DCGS.[19] AI/ML methods have many other applications beyond automation, however, in this report, we discuss the relevant AI/ML methods as a subset of automation to emphasize that they are but one approach to help automate AF DCGS processes. A key point is that automation is not an all-or-nothing proposition; there are many ways in which human analysts can use machines to accomplish analytic tasks. Less-complex automating techniques than AI/ML can also be valuable, as discussed among the recommendations below.

Levels of Automation

One way to think about the possibilities is to categorize different tasks by the *level of automation* they might entail (Figure 1.2).

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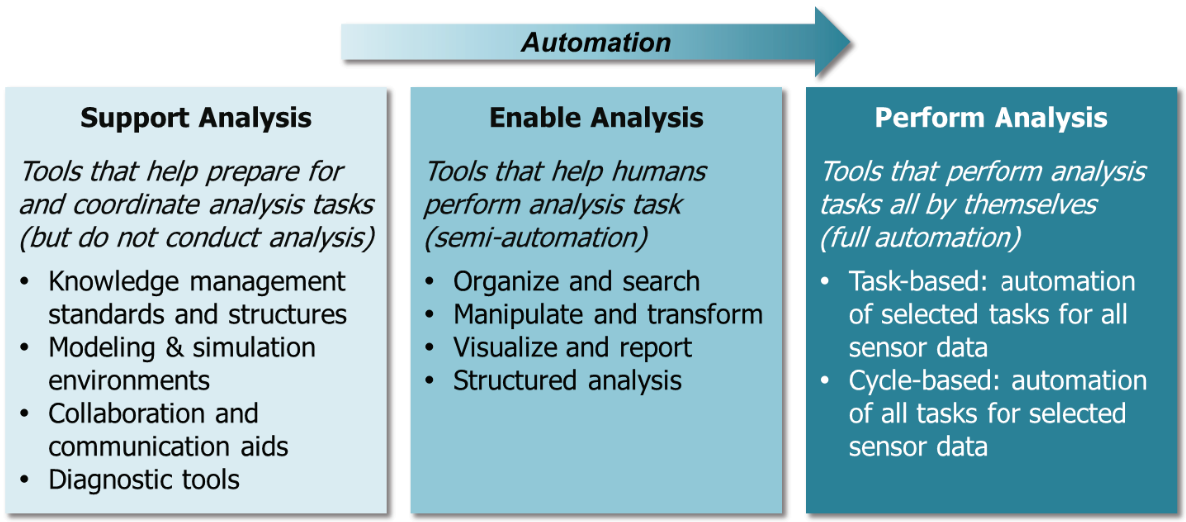
[17] Chapter 3 of Volume 2 (Menthe et al., 2021) presents historical case studies in which the AF DCGS and its precursors have confronted the challenges of achieving greater efficiency, effectiveness, use of human capital, and agility.

[18] Chapter 4 of Volume 2 (Menthe et al., 2021) provides a more-detailed primer on relevant AI/ML technology, maturity, and vulnerabilities.

[19] We also recognize that AI is not synonymous with ML. We discuss the distinction in Chapter 4 of Volume 2 (Menthe et al., 2021).

Figure 1.2. Levels of Automation



SOURCE: Adapted from Brien Alkire, Abbie Tingstad, Dale Benedetti, Amado Cordova, Irina Danescu, William Fry, D. Scott George, Lawrence M. Hanser, Lance Menthe, Erik Nemeth, David Ochmanek, Julia Pollak, Jessie Riposo, Timothy Smith, and Alexander Stephenson, *Leveraging the Past to Prepare for the Future of Air Force Intelligence Analysis*, RR-1330-AF, Santa Monica, Calif.: RAND Corporation, RR-1330-AF, 2017.

At the left end of the spectrum are tools that *support* analysis but do not perform any analytic functions per se. These tasks include knowledge-management practices, collaboration and communication aids, and diagnostic tools. For more-advanced analysis, such as technical electronic intelligence, modeling and simulation also may be part of the process. Many of these tools are available today and could be used to greater effect in the AF DCGS, as discussed in the recommendations on networking, hardware, and mission management later in this report.

The next level are tools that enable analysts to do more but still require a *human-in-the-loop* (i.e., at least one step in the process must be performed by a human). Examples include tools that organize and search, manipulate and transform, visualize and report, or perform structured analysis on data. As we discuss next, there is still a fair amount of low-hanging fruit in this area that the AF DCGS should consider as part of a broader AI/ML road map.

At the right end of the spectrum is full automation, which may be independent of human action or may include a *human-on-the-loop* (i.e., a human can choose to intervene, but the process will otherwise proceed automatically). This level includes tools that perform an entire analysis process. Generally speaking, these may be either *task-based*, where a single task (such as object recognition in an image) is performed for all collections of a certain format regardless of source; or *cycle-based*, where sensors may be automatically programmed to dynamically re-task themselves to improve collection as part of the larger intelligence cycle. As we discuss further, the AF DCGS can anticipate using fully automated tools, as they mature, in select parts of the enterprise, thus freeing analysts to focus on tasks that require human input and skill.[20]

Potential Applications

Based on our survey of the current mature AI/ML techniques,[21] we suggest a partial list of areas in which AI/ML could soon play a role in AF DCGS operations. Note that this is far from a complete list of AI/ML techniques, and there are many other AI/ML techniques that may be of interest to the AF DCGS in the future as new techniques mature and needs arise.[22] The AI/ML techniques discussed here may also be applicable to analysis processes, such as all-source intelligence analysis, that fall outside the AF DCGS portfolio.

Machine Vision

Machine vision seeks to process, analyze, and interpret visual data, either still or motion imagery. Currently, these systems can reliably recognize objects in video. Methods, such as "you only look once," can both identify that an image contains an object and specify where that object appears in the image (not necessarily the same task), as shown in Figure 1.3.[23] These techniques are sensor-agnostic, and, if provided with appropriate training data, should work with electro-optical, infrared, or synthetic aperture radar images, although outcomes will depend on the image quality.[24] Machine vision could potentially revolutionize geospatial intelligence (GEOINT), taking over such principal exploitation tasks as object recognition and scene captioning for high-altitude imagery and FMV. Machine vision could significantly reduce demands on human analysts and could apply more-consistent methodologies to a larger body of data than could a single analyst.

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[20] Note that this research focuses on task-based processes; AF DCGS does not have purview over the entire intelligence cycle, which also includes tasking and collecting.

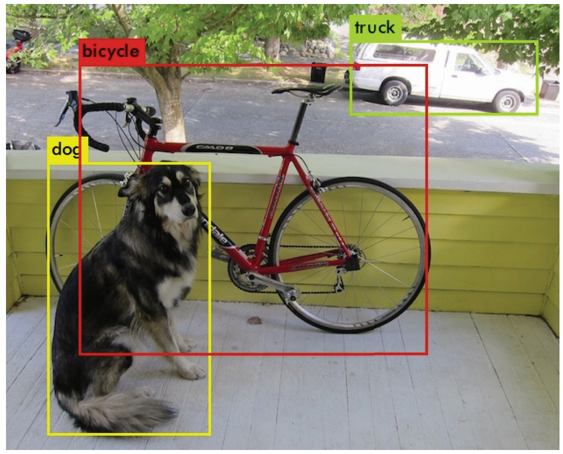
[21] We estimate that these techniques have a technology readiness level (TRL) of 9 or 10, according to the TRL scale proposed in Chapter 4 of Volume 2 (Menthe et al., 2021). Even if the algorithms and techniques are mature, however, the applications must still be developed, which requires large training sets and resources. Chapter 4 of Volume 2 discusses AI/ML techniques and their TRLs in greater detail.

[22] For example, AI/ML could be developed to detect whether an image has been tampered with, should that be an issue. See Yaqi Liu, Xiaobin Zhu, Zianfeng Zhao, and Yun Cao, "Adversarial Learning for Constrained Image Splicing Detection and Localization Based on Atrous Convolution," *IEEE Transactions on Information Forensics and Security*, Vol. 14, No. 10, October 2019.

[23] Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi, "You Only Look Once: Unified, Real-Time Object Detection," *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Las Vegas, Nev., 2016.

[24] The National Image Interpretability Rating Scale has been the standard method for describing image quality for the past 40 years. See, for example, John M. Irvine, "National Imagery Interpretability Rating Scales (NIIRS): Overview and Methodology," in Wallace G. Fishell, *Optical Science, Engineering and Instrumentation '97, Airborne Reconnaissance XXI*, San Diego, Calif., July 27–August 1, 1997, Vol. 3128, November 21, 1997.

Figure 1.3. Object Recognition and Location



SOURCE: Redmon et al., 2016.

However, machine vision still requires considerable experimentation and hand-tuning to give high-quality results in real-world applications. Current machine vision approaches tend not to work well when the objects they are "looking at" are not well-represented in the training set. They also require large amounts of training data. Thus, systems that perform well in peacetime may be unable to perform with a high level of confidence in new and unpredictable battlespaces.

Although promising, applications of machine vision to intelligence problems remain under development and are at various degrees of maturity. Although some basic tasks, such as *object recognition*, are relatively mature, more-complex tasks, such as *scene description* (i.e., generating text to describe what is in the image or the events or activity captured in a video), remain largely experimental and may be many years away from the kind of maturity needed for full integration into the analysis cycle. Commercially available machine vision systems are typically based on civilian research data sets (i.e., ImageNet), which are unlikely to be effective because they assume higher resolution, shorter range, and different viewing angles than are typical in Air Force intelligence collections (although these data sets may still be useful to pretrain an algorithm).

Facial recognition is an important subset of machine vision that seeks to reliably recognize specific faces, primarily for identification purposes. First, faces are distinguished from other parts of the image, then they are compared with known faces for similarities. In its advanced form, facial recognition aims to construct a multidimensional model of a face from a small number of two-dimensional images. The machine would then be able to recognize an individual from other two-dimensional images taken at different angles. High-quality commercial systems use such three-dimensional models; systems that rely solely on two-dimensional images in addition to some metadata have comparatively high error rates.

Facial recognition is now in commercial use, such as with the iPhone X, which can be unlocked by its owner's face, and for public surveillance in some countries. The ability to identify specific individuals in still images and video could have many concrete uses for the Air Force, such as increasing confidence in target identification and avoiding friendly fire incidents. However, some aspects of facial recognition would be more challenging for the Air Force than for commercial applications. Facial recognition can only work for faces that are already known; if there are only a handful of old pictures available, the face may not be known well enough to make a useful identification. Furthermore, images taken at greater distances and from less-favorable angles are likely to contain larger amounts of noise. For example, algorithms trained on standard headshots may not be effective at recognizing faces from above. Recent studies have also shown that, due in part to the training sets used, facial-recognition algorithms may be less capable of recognizing nonwhite faces.[25]

The AF DCGS could use machine vision today to assist human analysts in detecting potential threats, identifying specific known targets, and automatically tagging many classes of objects in still or video imagery. Building these applications, however, requires large amounts of training data, and the tighter the tolerances for error, the more training data are required. Until radically different AI/ML techniques are mature, substantial time and effort will be required to make effective machine vision–based applications for the AF DCGS.

Speech Recognition

Speech recognition aims to convert raw audio of speech into text. Because speech is not presegmented into distinct sounds, words, and sentences and varies considerably between individuals, converting it into text requires several models. First, an acoustic model attempts to translate raw audio into phonemes (i.e., distinct units of sound). The pronunciation model accounts for variations in these phonemes based on speaker characteristics, such as accent and gender. Finally, the language model converts the pronunciation model output into words. State-of-the-art research shows that the acoustic and pronunciation models can be combined and trained end to end. Integrating language models into this training is much harder, however. Although phonemes can be modeled fairly independently (i.e., spoken language is surprisingly similar to a random sequence of sounds), words and sentences are strung together with complex ordering rules that must be taken into account. As a result, these techniques often employ very large models that run on graphics processing units and require significant amounts of memory. This is a major reason why commercial speech-recognition systems (e.g., Amazon's Alexa) often run on a server rather than on client devices.

Speech-recognition technology is now in widespread commercial use (e.g., dictating to smartphones), although systems vary in quality. A high level of success has been achieved with speech recognition in many languages, including tonal ones, such as Mandarin. This technology

[25] Kottakkal Sugathan Krishnapriya, Kushal Vangara, Michael C. King, Vitor Albiero, and Kevin Bowyer, "Characterizing the Variability in Face Recognition Accuracy Relative to Race," *2019 IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, Long Beach, Calif, June 16–17, 2019.

has the potential to considerably augment the effectiveness of trained linguists and increase the capacity to analyze materials in unfamiliar languages.

However, speech recognition cannot work better than underlying acoustic, pronunciation, and language models, and the relevant information to develop these may not be available for certain languages of interest. Speech recognition is also subject to the "cocktail party problem": The machine can have difficulty distinguishing a conversation of interest from other concurrent speech. Recent research using visual cues to disambiguate speakers suggest that this challenge may soon be partially alleviated.[26]

AI/ML offers great promise in this area, but the challenges are also very difficult. As with machine vision, it will require substantial effort to develop AI/ML speech-recognition applications that are valuable to the AF DCGS. Fortunately, the IC has already made substantial investments in this area.

Language Translation

Language-translation systems seek to translate text (generally not audio) from one language to another. Machine language-translation systems were among the earliest commercial AI applications, although initial results were very poor. Today, automated language translation is a core service provided by major technology companies, such as Google and Baidu.

In some ways, translation is easier than speech recognition, both because high-quality bilingual training data exist for many languages and because the data are already clearly divided into "tokens"—characters, words, and sentences. Systems can be trained to digest these tokens and output them in the target language. Presently, nearly all language-translation systems use supervised learning (i.e., a human actively teaches the rules to the machine), but researchers have demonstrated preliminary results for unsupervised language translation without such aids.[27] Such an approach might be useful for working with more-obscure languages.

The ability to translate textual information from difficult or obscure languages could reduce the burden on skilled AF DCGS linguists and allow faster analysis of intelligence data collected in foreign languages. However, although state-of-the-art machine translation systems can give impressive results, they do not actually *understand* the text in a meaningful sense and instead rely largely on statistical correlations between word and phrase occurrences in the two languages.[28] Many systems also have a limited or nonexistent understanding of grammar, which

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[26] Ariel Ephrat, Inbar Mosseri, Oran Lang, Tali Dekel, Kevin Wilson, Avinatan Hassidim, William T. Freeman, and Michael Rubinstein, "Looking to Listen at the Cocktail Party: A Speaker-Independent Audio-Visual Model for Speech Separation," *ACM Transactions on Graphics*, Vol. 37, No. 4, Article 112, August 2018.

[27] Mikel Artetxe, Gorka Labaka, Eneko Agirre, and Kyunghyun Cho, "Unsupervised Neural Machine Translation," paper presented at the Sixth International Conference on Learning Representations, Vancouver, Canada, April 30–May 3, 2018.

[28] Another option is using linguistic AI/ML tools that work natively in a different language. However, translation into English is likely to be deemed necessary in most cases before the intelligence can be considered actionable.

is treated incompletely or not at all by the underlying model. As a consequence, even a high-quality system may generate output whose grammar, syntax, semantics, and pragmatics are all misleading or completely wrong. As with speech recognition, this is an area where the substantial investment required to make applications sufficiently reliable for the AF DCGS has already been made, or is being made, by other parts of the IC.

Waveform Phenomenology

Identifying waveform phenomenology is the heart of electronic intelligence. Regarding AI/ML implementation, waveform phenomenology has a surprising amount in common with speech-recognition tasks. Indeed, the "acoustic model" at the front end of many speech-recognition systems is essentially an audio waveform comparison system. Modern ML offers a variety of tools for these purposes. Techniques employed in speech recognition (e.g., methods that divide recorded audio into variable-length segments, such as phonemes or words[29]) are also likely to be useful. In addition to the time-based characteristics of the signal, ML and neural networks can also be applied to spectral analysis tasks to identify previously undetected signals of interest in noisy data. These networks can also address physical characteristics of the signal, such as direction finding.

There has been tremendous research on detecting true signals from noisy data. One ML-related success worth noting is the analysis of hydrophone data for locating submarines, which was one of the earliest practical applications of neural networks in the late 1980s.[30] However, an important consideration here is that appropriate training data may not be available in advance for certain signals of interest. Moreover, adversaries are developing software-programmable systems that can mimic almost any waveform, even noise-like ones, which makes their detection and identification much more difficult.

For most basic waveforms, the process of detecting signals within collected data is already largely automated today. For many advanced waveforms, development of detection algorithms would be straightforward and not require AI/ML. For the most difficult waveforms, however, especially noise-like ones for which AI/ML techniques likely would be required, a substantial effort will be needed.

Text Summary and Narrative Synthesis

Text summary and narrative synthesis technologies seek to reduce texts to natural-language summaries or to write stories. These were first pioneered using symbolic AI techniques in the

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[29] See, for example, Awni Hannun, "Sequence Modeling with CTC," *Distill*, November 27, 2017.

[30] Donald F. Specht, "Applications of Probabilistic Neural Networks," in Steven K. Rogers, ed., *Applications of Artificial Neural Networks, Proceedings of the 1990 Technical Symposium on Optics, Electro-Optics, and Sensors*, Orlando, Fla., April 16–20, 1990, Vol. 1294, August 1, 1990.

1970s.[31] Text summary and narrative synthesis systems have been in limited commercial use for such purposes as sports and business reporting for some time.[32]

Mature text summary and synthesis systems could facilitate the exploitation and dissemination of open-source intelligence (OSINT) and SIGINT, thereby reducing analyst effort. Text summarization could save manpower by allowing analysts to read concise summaries instead of scanning entire documents. Sophisticated narrative-generation systems could potentially automate more-advanced forms of exploitation, producing research products with less human input. Current research suggests that these could include both machine-generated text, illustrations, and graphs.[33]

Current text summary and synthesis systems have significant limitations, however. Historical symbolic narrative synthesis programs "understood" narrative elements and reasoned with them predictably but required hand-engineered knowledge bases. Because of their limited knowledge, these systems were brittle and could only work in very narrow domains (e.g., sports games). More-recent AI/ML techniques can give reasonable results on a wider range of texts but do not "understand" the text being summarized or synthesized. The resulting synthesis can, on occasion, be so incorrect as to be nonsensical. The recent introduction of pretrained language models that are analogous to models pretrained for image processing may alleviate, but not eliminate, these problems.

How Soon Can the Promise of Artificial Intelligence/Machine Learning Be Realized?

The overview just presented suggests that emerging AI/ML capabilities have enormous promise for AF DCGS tasks but that much work remains. Past predictions of how quickly AI/ML will mature have proven unreliable, sometimes overly optimistic, and sometimes missing significant advances. On the one hand, many early AI researchers mistakenly thought that "human-level" AI would be created well before the start of the 21st century. On the other hand, as recently as ten years ago, the imminent conquest of AI/ML by deep learning was far from obvious, even to most leading researchers. Although we can estimate the TRLs for the major AI/ML methods being developed today,[34] even this rough estimate of current maturity is no indicator of future progress.

Given this uncertainty, we group our recommendations for AF DCGS into (1) those that can be implemented using today's technology without significant changes to AF DCGS hardware or

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[31] Christopher K. Riesbeck and Roger C. Schank, eds., *Inside Computer Understanding: Five Programs Plus Miniatures*, Hillsdale, N.J.: Lawrence Erlbaum Associates, Inc., 1981.

[32] National Public Radio, "Program Creates Computer-Generated Sports Stories," *All Things Considered*, January 10, 2010.

[33] For an amusing example, see Chelsea Whyte, "AI Created Images of Food Just by Reading the Recipes," *New Scientist*, January 10, 2019.

[34] In Appendix A of Volume 2 (Menthe et al., 2021), we propose a TRL scale for AI/ML and apply it to current technologies.

network architecture and (2) those that require AI/ML applications to be developed (or leveraged from partner organizations where possible). Many of the recommendations in the first category will pave the way for those in the second, but all the recommendations should be useful to analysts if and when they are implemented. Finally, we reiterate that AI/ML technologies cannot simply be plugged into the AF DCGS enterprise whenever they become available; a third category of recommendations addresses the human factors of organization, training, and culture that must accompany and even precede technological improvements.

Making the Most of Today's Technology

The first category of recommendations consists of what we consider to be low-hanging fruit: improvements that can be implemented using today's technology without significant changes to the AF DCGS hardware or network architecture. These are summarized in Table 1.1 and grouped into the categories of GEOINT, SIGINT, networking and hardware, and mission management. For each recommendation, the table shows the analysis roles that are affected (using the taxonomy of roles introduced in Figure 1.1) and which objectives they help meet. Most of these recommendations aim to free analysts from some of the more tedious and time-consuming tasks they currently must perform or to build the back-end data management capabilities needed to conduct multi-INT analysis of higher-level intelligence problems.

Table 1.1. Recommendations: Making the Most of Today's Technology

Category	Summary of Recommendation	Analysis Roles Affected	Objectives Addressed
GEOINT	Create a geospatial intelligence analysis and reporting tool (GEOART) to semiautomate product generation and mission reporting.	Reporter	Efficiency Human capital
	Create an improved formatter to assist with threat warning.	Reporter	Efficiency
	Create a linker tool to tie information used to confirm the exploitation back to the source.	Exploiter Investigator	Effectiveness
	Adopt geographic information systems (GISs) into the moving target indicator (MTI) workflow.	Exploiter Investigator	Effectiveness Agility
	Bring in programmers to write Python scripts to automate analysis processes within GIS.	Exploiter Reporter	Efficiency
	Assess risks and benefits of adopting the industry standard in video editing tools for wide-area motion imagery (WAMI).	Exploiter Investigator	Effectiveness Agility
SIGINT	Create a Scraper script to ensure that threat-warning messages are captured in mission reports.	Reporter	Efficiency Effectiveness
	Create various scripts to transform or eliminate the technical reporter (TR) position.	Reporter	Efficiency Human capital
	Overcome barriers to using partner networks to pave the way for leveraging future capabilities.	Exploiter Investigator	Effectiveness Agility
Networking and hardware	Support and renew the open-architecture (OA) DCGS rollout.	Exploiter Reporter	Agility
	Address networking problems.	Investigator Reporter	Efficiency Effectiveness Agility
	Address switchbox and hardware issues	All roles	Efficiency
	Involve DGS-3 early in the development and user engagement process.	All roles	Agility
Mission management	Built on current efforts to produce a more-effective mission management tool suite.	Supervisor	Efficiency Human capital Agility

Geospatial Intelligence

GEOINT is the analysis of imagery and other georeferenced information. As just discussed, current analytic processes include a great deal of cutting and pasting, manual entry of metadata from one system to another, and manual preparation of products with various formatting requirements. For high-altitude imagery, most of the analyst's time is spent formatting, not analyzing. AF DCGS can begin to speed up these processes for GEOINT by making use of commercial off-the-shelf (COTS) technologies or creating specialized tools that are within reach today by doing the following:[35]

- **Create a GEOART to semiautomate product generation and mission reporting.** GEOART would take images selected by analysts and create reports in appropriate formats. Humans may still need to add annotations manually, until the technology matures to permit automated tagging of information. As described later, this tool has many capabilities. Some of them would be relatively simple, but others would require significant development effort. This capability would increase efficiency and would make better use of human capital.
- **Create an improved formatter to assist with threat warning**. Instead of hand-jamming information into a web interface, which is the current practice, analysts would need only to make a few clicks to send relevant metadata to warning systems in the appropriate formats. This would be especially efficient for real-time intelligence, which requires frequent updates of warnings.
- **Create a linker tool to tie information used to confirm the exploitation back to the source.** This step (rarely performed because it is time consuming to do by hand) would pave the way for eventual backtracing of exploitation to collections, making future analysts more effective.
- **Adopt GIS into the MTI workflow.** This standard COTS system could be automated with appropriate Python scripts to perform many of the tasks currently done in a more manual way with various custom tools and Excel.
- **Bring in programmers to write Python scripts to automate analysis processes within GIS.** Making this work for GIS would also help pave the way for wider adoption of GIS into future GEOINT analysis.
- **Assess risks and benefits of adopting the industry standard in video-editing tools for WAMI.** AF DCGS should investigate alternative video-editing platforms, including Avid, the standard tool used in film and television today. The intent would be to make more effective use of WAMI collections than is possible today. Moreover, because Avid has the widest commercial user base, any industry AI/ML innovations applicable to WAMI analysis are likely to be designed for this product.

These steps would use existing capabilities to reduce duplication of effort and standardize workflows for many of the GEOINT analysis tasks that are currently time consuming for human analysts.

Signals Intelligence

SIGINT is the collection discipline that is most burdened by outdated hardware and software in the AF DCGS. Although certain older systems are being retired, the rollout of replacement systems has been challenging. The new signals-analysis workstation, which finally completed its long rollout in 2018, promises to enable one analyst to do the work of two or more for some

[35] We elaborate on the GEOINT recommendations in Chapter 5 of Volume 2 (Menthe et al., 2021).

tasks. Initial user experience with the new system, however, has been less than successful.[36] As several analysts explained, the problem goes beyond having a different format for menus and structure; the new system appears to use "different names for everything," which confuses analysts and adds unnecessary retraining time. This is unfortunate because the new system is technically superior to the old one. This experience is one reason why we stress the importance of correctly implementing new systems to ensure smooth adoption by the users they are meant to help.

The AF DCGS can further improve SIGINT in the near term. We suggest that the AF DCGS create a Scraper script to ensure that threat-warning messages are captured in mission reports. This script would automatically (and efficiently) add metadata from the warning message into mission reports and other technical summaries. This is necessary because threat warnings require the use of certain legacy systems outside AF DCGS control. SIGINT is also an area where partner tools can be leveraged to good effect. We recommend that the AF DCGS support efforts to move data quickly to partner networks, where better tools can be used and accessed. This will prepare the enterprise to leverage still more powerful AI/ML tools developed by the IC in the future, as discussed in the next section.

Networking and Hardware

The OA DCGS is another technically superior system that has experienced rollout difficulties. OA DCGS is a replacement built on modern, open standards for the primary computer system that the AF DCGS uses today. At its current resourcing level, OA DCGS is not expected to be fully deployed across the enterprise until 2021. Part of the reason for the slow rollout is that there have been persistent issues with ingesting data from other AF DCGS systems.[37] Sufficient resources must be provided to fix these integration issues and to allow the rollout to proceed more rapidly. OA DCGS is a critical step toward integrating future COTS technologies, as well as leveraging future AI/ML advances as they become available.

There are additional networking issues within the AF DCGS that should be addressed in the near term. At some DGS sites, access to the Joint Worldwide Intelligence Communications System (JWICS) can be temperamental, and this should never be the case within a weapons system that requires connectivity to function.[38] Moreover, the official installations are sometimes limited in capability.[39] Some sites also have intermittent problems with switchboxes between classified and unclassified systems. Analysts raised with us the risk that, because of these glitches, an airman might accidentally enter sensitive information into the wrong system.

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[36] One meme we saw posted in an analysts' ready room compared using the new system unfavorably to a migraine.

[37] An analyst interviewed during a user evaluation test confided, "It's the same problem they've had for a year."

[38] At one site, one of the authors was directed to a JWICS system that refused to load, then froze. "Does anyone have a terminal that works today?" was, evidently, a common question there.

[39] One airman described it as "like we got a bootleg copy from Afghanistan."

Without addressing these network issues, the AF DCGS cannot be fully effective, efficient, or agile: Even the most rapid and accurate analysis process is not useful if its fruits cannot be reliably disseminated to those who need it.

Finally, adoption of new systems is more challenging at DGS-3 than elsewhere in the AF DCGS enterprise because of special network needs as a result of its location in South Korea. As a result, analysts there are often forced to use older tools and fat-finger additional data from one system to another. This is not only a problem for DGS-3 but for other AF DCGS locations that share its mission or provide backup. Because of these differences, it appears that many developers prefer to leave DGS-3 to be addressed until the end. Unfortunately, this sometimes means its needs never get addressed. We recommend involving DGS-3 much earlier in the development process. This not only ensures the analysts receive the attention they require, but also places greater emphasis on the kind of network-integration issues that have been underestimated for recent new systems. As one DGS-3 analyst explained: "If they can make it work here, it will work anywhere."

Mission Management

One of the core competencies of AF DCGS is supporting its own analytic processes. A mundane yet critical part of this function today is to populate each crew on the operations floor with analysts who have the right skills and qualifications to support the missions being flown that day. Unfortunately, the systems that create the daily PED tasking order are distinct from those that keep track of AF DCGS training qualifications and that manage personnel shift schedules. Moreover, because of network-certification issues, distribution mission and DGS sites must use different methods for scheduling personnel. As a result, planning is unnecessarily time-intensive and nonstandardized.

The 480th Intelligence, Surveillance and Reconnaissance Wing has been developing a quick-turnaround solution, Narwhal, but this could only be a first step. A new mission-management system for assigning analysts to missions that integrates all necessary information and allows for rapid consideration of "what if" scenarios would improve efficiency and allow supervisors to handle and/or make allowances for contingencies—for example, when support for a mission must abruptly be shifted from one site to another because of networking issues. At many AF DCGS locations, one or two individuals spend most or all of their time using Excel and a whiteboard to manage an increasingly complex scheduling process. Without appropriate attention, what is merely an irritation today could become a bottleneck in the future, especially as the AF DCGS shifts away from the current linear model toward SIAS.

A new mission-management system would also make it easier for individual DGS sites to experiment with more-flexible work schedules, which could have a significant positive impact on morale and performance. In some ways, this would build on existing efforts to improve shift work, including pursuing "sun synchronous" operations for some personnel so that there are fewer analysts working nights.[40]

The AF DCGS works across many time zones. An improved mission-management system would also enable future planners to attempt *enterprise-level* adjustments to manpower-allocation formulas and to address other inefficiencies that would be simply impractical to address at the Wing level today. As with the rest of the tools recommended in this section, an improved mission-management system could be built with today's technology; AI/ML techniques are not needed. It is largely a matter of allocating resources and combining information from databases that do not currently talk to one another or that live on separate networks.

Taking Advantage of Future Technology

The previous category of recommendations sets the conditions necessary to integrate AI/ML into the workflow and removes obstructions to its success. The next category consists of more-complex changes: improvements that require technical thresholds to be achieved before they can be implemented (e.g., developing new AI/ML algorithms) or significant adjustments to the current AF DCGS network architecture. These recommendations are given in Table 1.2. Many of these steps are intended to support a partial shift in human effort from Phase 0 and Phase 1 analysis tasks (e.g., determining whether the collection is useful, issuing immediate threat warnings, answering basic "who, what, when, and where" questions) toward more Phase 1.5 analysis and above (e.g., correlating information from multiple sources to provide operational context, answering questions of why and how, fusing multi-INT information to answer intelligence questions, providing all-source analysis).[41] We also suggest areas where the AF DCGS could leverage IC and partner tools to make multisource information more available to intelligence analysts.

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[40] The phrase *sun synchronous* is not ours; it is a play on a term from satellite operations: A satellite in a sun-synchronous orbit passes over the same point at the same local solar time. One of the problems with supporting operations in a distant time zone is that the need for real-time intelligence does not fall within regular business hours. Here, *sun synchronous* simply means allowing more analysts to work during regular business hours by postponing non-time-sensitive work until the day shift. Note that the *collection* operations are unaffected.

[41] Chapter 1 of Volume 2 (Menthe et al., 2021) describes the phases of analysis used in this project. Briefly, Phase 0 consists of quick judgments within seconds or minutes; Phase 1 consists of basic analysis within minutes to hours; Phase 1.5 includes multisource correlation of different collections within hours to days.

Table 1.2. Recommendations for Taking Advantage of Future Technology

Category	Summary of Recommendation	Analysis Roles Affected	Objectives Addressed
GEOINT	Use AI/ML to perform Phase 0 analysis and dynamically re-task collectors with human-in-the-loop (or on the loop, depending on how the mission control element evolves).	Exploiter	Efficiency Effectiveness
	Use AI/ML to perform partial Phase 1 analysis (e.g., tag imagery, identify objects and people).	Exploiter	Efficiency Effectiveness
	Use AI/ML to notify analysts of significant changes in activity and generate threat warnings with in-the loop.	Exploiter Reporter	Efficiency Effectiveness Human capital
	Use AI/ML to pore through archived FMV and WAMI footage to apply partial first-phase exploitation to all and create data sets sharable with the IC.	Investigator	Agility
	Seek to lift the "eyes-on" requirement for FMV missions where the ISR role indicates no risk of troops in contact or strike decisions and when AI/ML tools can alert human analysts to other events that require real-time judgments.	Exploiter	Efficiency Human capital
SIGINT	Leverage IC and partner capabilities for analysis but maintain organic capabilities for threat warning.	Exploiter	Efficiency Effectiveness Agility
OSINT	Leverage IC and partner capabilities for analysis.	Investigator	Effectiveness
Multi-INT	Leverage IC and partner capabilities for analysis.	Investigator	Effectiveness Agility
	Assess as soon as possible the potential for cloud computing to be the centerpiece of the next hardware refresh, including whether the AF DCGS should participate in IC clouds and/or develop its own.	All roles	Efficiency Quality Effectiveness Agility

Geospatial Intelligence

As AI/ML technologies mature, we anticipate that they will begin to contribute to GEOINT analysis in the ways listed in the bullets below. As detailed in Volume 2, we do not expect these steps to be accomplished at once; incremental progress requiring human-machine collaboration will likely be the norm.[42]

- **Use AI/ML to perform Phase 0 analysis and dynamically re-task collectors.** A machine would view all collections to determine whether they are usable and would automatically request a new collection if necessary. Until the collection platform itself is more automated (beyond the scope of this project), the re-tasking process would likely still require some human intervention.
- **Use AI/ML to perform partial Phase 1 analysis.** This would include such basic tasks as tagging imagery and identifying objects and people. Machines are unlikely to be

[42] See Chapter 5 in Volume 2 (Menthe et al., 2021) for more detailed discussion of these GEOINT recommendations.

sophisticated enough to interpret human actions (at least for some time), so human analysts would still play a role in this step. Significant efforts are currently underway to develop these tools, notably Project MAVEN, as discussed in Volume 2.[43]

- **Use AI/ML to alert human analysts of significant changes in activity and generate threat warnings with humans-in-the-loop.** If the human agrees to issue the threat warning, then the automated reporting and archiving tools discussed in the preceding section would come into play.
- **Use AI/ML to pore through archived FMV and WAMI footage** to apply partial first phase exploitation to all and create data sets sharable with the IC. This makes use of the wealth of data already collected in two ways: by searching for new information in old collections and by using that exercise to generate training data that may be used for other purposes by partners.
- **Seek to lift the eyes-on requirement for FMV missions where possible.** There is currently a requirement for an analyst to have eyes on an FMV feed at all times—largely when nothing is happening. Previous PAF analysis shows that this can have a serious impact not only on the number of people required but on morale.[44] When AI/ML becomes reliable enough to detect significant events as well as human analysts do, then the AF DCGS may be able to lift the eyes-on requirement for some missions—notably those that do not involve risk of troops in contact or strike decisions. The machine would flag human analysts when something happens and when human judgment is needed.

Increased automation of key GEOINT processes will improve both efficiency (by reducing human time and effort) and effectiveness (by making collections more easily sharable and findable through tagging). It will also enable a better use of human capital by allowing analysts to focus on higher-phase analysis and intervene in lower-phase tasks only when needed.

Signals Intelligence

The AF DCGS lacks the resources to make the kinds of large-scale investments that will be required to achieve AI/ML breakthroughs in all relevant collection disciplines. SIGINT is one discipline where the Air Force should work to ensure appropriate access to partner networks and IC capabilities so it can leverage new tools as they are developed by others. As the AF DCGS does so, however, it is important that it retains its ability to provide threat warnings in real time.

Open-Source Intelligence

As with SIGINT, other organizations are pursuing OSINT more vigorously than the AF DCGS can afford to do, given everything else that they must accomplish. Moving to OA, improving network access, and overcoming policy barriers that restrict analysts' ability to work with PAI will enable the AF DCGS to leverage these partner tools and information as they become available.

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[43] See Chapters 4, 7, and 8 of Volume 2 (Menthe et al., 2021).

[44] Menthe et al., 2012.

Multi-Intelligence Fusion

The National Reconnaissance Office and other agencies have proven that AI/ML techniques can be applied to both early and later-phase analysis involving deeper levels of synthesis. The DART already uses some of these tools, and others are available. The Air Force should not reinvent the wheel where such tools are available. We recommend the same here as for SIGINT and OSINT: The AF DCGS should work to overcome policy barriers now—in particular, those associated with sharing SIGINT data—so that it can leverage the work of others in the future.

Cloud Computing

One way that the AF DCGS can prepare itself is to move toward cloud computing. This move is well underway in other parts of the IC. Cloud computing offers several advantages. For example, servers can be scattered geographically, thereby making the overall network more resilient to disruption. Depending on how permissions are implemented, cloud computing could enable all tools to be available to authorized users at all locations. For tool development purposes, bug fixes and security patches can be deployed incrementally and seamlessly instead of requiring disruptive system updates at infrequent intervals. Cloud computing analytics can also provide leadership with easier access to metrics, such as how often intelligence products are viewed or software tools are used.

Cloud computing provides a better environment for development and integration of AI/ML tools than conventional network structures, particularly for applications where specialized hardware would be needed for real-time processing. For this reason, AF DCGS's adoption of an OA should be only a first step. Planning for the next hardware refresh should begin as soon as possible. The question should shift from "Should the AF DCGS adopt cloud computing?" to "How can we make cloud computing work best for the AF DCGS?" The answers should include determining whether the best structure involves joining IC clouds and/or developing a separate cloud specific to AF DCGS needs.

Addressing Human Factors

As just discussed, improving AF DCGS operations is not simply a matter of replacing analysts and operators with automating technology in certain areas. It is also about using automating technology to help analysts and operators to do their best. Analysis is not a burdensome step in the intelligence cycle that should be eliminated but a critical step that should be strengthened—and analysts will continue to play key roles in many analytic processes for the foreseeable future. AI/ML tools must be developed, tested, launched, and maintained. Operators must be trained to use them effectively. Analysts must also retain skills to step in when machines fail or reach the limits of their capability. The technology improvements recommended in this report cannot be fully realized without a balanced and adaptable organizational structure, new skills and training, and a culture that fosters innovation and successful implementation. Our recommendations in these areas are summarized in Table 1.3 and in bullet points below.

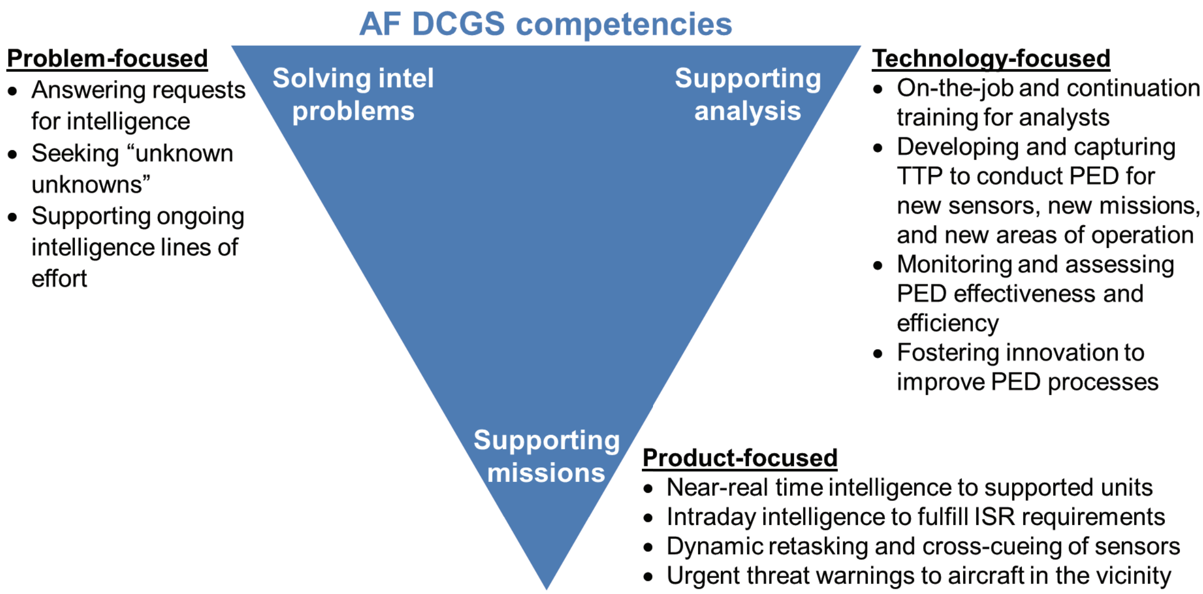
Table 1.3. Recommendations for Addressing the Human Factors

Category	Summary of Recommendation	Analysis Roles Affected	Objectives Addressed
Competencies and organization	Pursue a balanced approach that retains all three AF DCGS competencies: supporting missions, supporting analysis, and solving intelligence problems.	All roles	All objectives
Skills	Retain basic intelligence skills for some airmen, even where they may appear obsolete because of AI/ML	Exploiter	Agility
	Teach GIS basics at Goodfellow Air Force Base (where the 17th Training Group provides the DCGS Formal Training Unit).	Exploiter Investigator Reporter	Effectiveness Human capital
	Encourage use of certificates for data science and programming. – Consider expanding the Combat Readiness Sustainment Program (CRSP) program. – Make use of time while analysts wait for their security clearances.	Exploiter Supervisor	Effectiveness Human capital Agility
	Support and expand rehearsal-of-concept (RoC) drills.	All roles	Effectiveness Agility
	Hold an annual weapons and tactics (WEPTAC) conference for sharing best practices among AF DCGS sites, particularly the DARTs.	Investigator Supervisor	Efficiency Effectiveness Agility
	Encourage CCMDs to allow AF DCGS to provide support via mission type orders (MTOs) and focused collection operations.	Supervisor	Human capital Agility
Innovation and implementation	Follow best practices for technology innovation and implementation.	Supervisor	Efficiency Effectiveness Agility
	Emphasize user engagement at each stage.	Supervisor	Human capital
	Identify opinion leaders and champions at DGS sites to foster tool development.	Supervisor	Human capital
	Reward innovators with time to sustain their own innovations and to build new things.	Investigator	Human capital
	Create a process for gracefully offboarding old tools.	Supervisor	Efficiency

Rebalancing Air Force Distributed Common Ground System Competencies and Organization

The AF DCGS has three main competencies, illustrated in Figure 1.4. Although the AF DCGS presently works in all of these competencies, the weight of effort is primarily on *supporting missions* by conducting PED for the massive amount of collected data. The AF DCGS is structured accordingly, with operations floor crews organized around specific platforms or types of intelligence. The introduction of AI/ML to perform or assist with many analytic tasks (as recommended above) presents an opportunity for the AF DCGS to rebalance its weight of effort among the three competencies and to organize itself for greatest agility.[45]

Figure 1.4. Air Force Distributed Common Ground System Competencies



NOTES: TTP = tactics, techniques, and procedures.

One option would be to shift the bulk of human effort from conducting PED on incoming collections to *solving intelligence problems* posed by warfighters. Such a move would imply a *problem-focused* (versus a *platform-* or *INT-focused*) organization, with individual teams dedicated to addressing specific problems or supporting particular ground units or areas of operation. The advantages would be more-effective support to warfighters and better use of human capital.

Another option would be to focus greater human effort on *supporting analysis*: continually developing and improving tools and technologies to make the other two competencies more efficient and to facilitate the use of AF DCGS products in later-phase analysis by other parts of the IC. Some of this already takes place informally, as self-motivated analysts make time to fix or improve upon the tools they use. A more-deliberate approach would dedicate sites or teams to specific technical problems, such as automating particular data formats or creating better tools to integrate multiple intelligence sources.

We recommend that the AF DCGS take a *balanced approach* that keeps the organization agile and responsive to evolving needs. This does not necessarily mean that each site must perform all competencies equally. For example, one site might focus on solving intelligence

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[45] The rebalancing of AF DCGS competencies is discussed further in Chapter 6 of Volume 2 (Menthe et al., 2021).

problems in a particular theater, while another might serve as a test bed for new AI/ML tools. We may also envision a DGS location with different parts organized around different analysis phases so that basic questions of who, what, when, and where would be answered by AI/ML while data are being collected; more-advanced questions of why and how would be answered by humans who would be drawing on well-organized and accessible databases to meet warfighter demands. Some part of the organization could be dedicated to improving tools that support both humans and machines.

The balanced approach also allows for improved scalability. Currently, the AF DCGS analyzes all data (except WAMI) as soon as they are ingested, answering both basic and advanced questions for all collections. Therefore, human workload scales directly with input. Greater automation, especially to answer basic questions with high confidence, could change that equation; human analytic effort could be freed from specific platforms or data sets and applied more judiciously to the most-pressing needs.

It is important to note that such a structure is still aspirational, because it would depend on AI/ML technologies discussed earlier being mature enough to perform many analytic tasks at least as well as humans do. Moreover, we reiterate that humans would never be entirely cut out of the analysis process; even highly automated processes would continue to involve humans-in-the-loop or on-the-loop as appropriate, and humans must be ready and able to step in and perform some tasks if machines cannot (e.g., if algorithms fail or if networks are attacked).

The essential point is that the AF DCGS would have the organizational flexibility to take advantage of what AI/ML can do to employ humans where they add greatest value, develop better ways of supporting both machines and humans, and shift among these priorities as circumstances require.

Building the Right Skills

Analysts will need to cultivate new skills—and retain some old skills—to thrive in the future AF DCGS described. We recommend that the AF DCGS take the following steps to prepare airmen analysts:[46]

- **Retain basic intelligence skills for some airmen.** Reliance on AI/ML to perform basic analytic tasks introduces a potential vulnerability if those systems should fail or suffer under attack. The AF DCGS should ensure that some human analysts retain the skills to step in if necessary.
- **Teach GIS basics at Goodfellow Air Force Base.** We recommend using GIS for certain types of GEOINT analysis. This is an emerging IC standard. Analysts should receive instruction in GIS basics as part of intelligence visualization training at Goodfellow.[47]

[46] These steps are explored further in Chapter 7 of Volume 2 (Menthe et al., 2021).

[47] Older visualization tools, such as FalconView, might be retired from classroom instruction to help make room.

- **Encourage certificates for data science and programming.** Those who support analysis will need a basic understanding of programming to appreciate what AI/ML can and cannot do and to have the technical literacy to communicate AF DCGS needs to professional programmers. Without this, user engagement and user-evaluation exercises between programmers and analysts would be less fruitful. We recommend that the Air Force look to certificate programs that can provide airmen with a technical grounding and basic competency. One option would be to extend the CRSP to provide additional opportunities for mid-career training. For example, a CRSP+ program could provide more time for airmen to gain the technical skills needed to support analysis and to help guide innovation. A further step would be to encourage airmen to take advantage of university and college certificate programs during the unfortunate downtime that often occurs while they wait for their clearances.
- **Support and expand RoC drills.** RoC drills are tabletop exercises intended to train airmen in roles, tools, processes, and team collaboration using imaginative vignettes. These exercises could be expanded to address multi-INT capabilities and the introduction of new types of sensor data and analysis tools in the AF DCGS. AF DCGS intelligence training guidance allows for tabletop certification of analysts in new mission areas under certain circumstances.[48] RoC drills specifically designed to explore these new mission areas may be useful in this regard.
- **Hold annual ISR weapons and tactics conference to share best practices.** Individual analysts or sites sometimes develop new methods or adopt helpful tools to improve analysis, but complexity, lack of communication, and even lack of trust can hinder wider implementation across the AF DCGS. Weapons and tactics (WEPTAC) conferences can help spread good ideas throughout the enterprise.
- **Use mission type orders and focused collection operations as test beds.** The Air Force should encourage CCMDs to allow AF DCGS analysts to become more engaged in ISR operations through mission type orders (MTOs) and focused collection operations. These opportunities would help analysts discover new ways to solve difficult ISR problems and better understand the operational context for their work.

Fostering Innovation and Successful Implementation

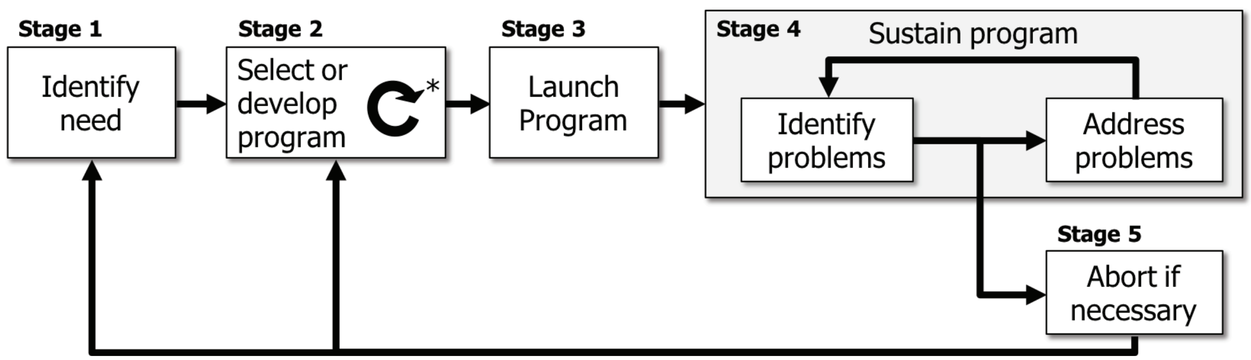
Training alone is not enough to ensure that new tools will deliver their promised benefits. Analysts we spoke with emphasized that the *way* in which new tools are developed and introduced into the AF DCGS matters. Even the most powerful AI/ML tools are unlikely to make a difference if they do not meet—and *appear* to meet—analyst needs, if analysts are not adequately trained and prepared to use them, if they are not continually monitored and fixed as problems inevitably arise, or if old systems are retained beyond their usefulness.

The primary recommendation is to follow best practices established by other organizations for developing and implementing new technologies, tools, and processes. From our analysis of

48 Air Combat Command Instruction 14-201, *Distributed Common Ground System (DCGS)–Intelligence Training*, Vol. 1, Joint Base Langley-Eustis, Va., February 5, 2018.

case studies,[49] we found that successful implementation involves five major stages, shown in Figure 1.5. Implementation is not a one-time linear process but rather a cycle of continuous innovation, assessment, and improvement.

Figure 1.5. Stages of Technology Implementation



NOTE: * = The development cycle involves rapid iteration through multiple builds.

The precise stages need not be formalized, but the AF DCGS should heed certain key lessons. The most important is that engagement with end users—the analysts—is critical at every stage: to identify needs, articulate those needs, and evaluate whether needs are being met. The Air Force should also identify opinion leaders and champions to spearhead implementation—and these individuals should be volunteers, not "volunteered." Lack of enthusiasm about the proposed new system would be an important warning sign. Moreover, compliance and integration issues should be addressed early in the process rather than left until the end.

The AF DCGS should provide incentives to reward innovators. One of the simplest (and least expensive) ways is simply to recognize the efforts of airman innovators by affording them additional time to do such work and to help bring what they have already created to completion. This is a win-win outcome for the organization and the innovator: Although it may seem counterintuitive that "getting to do more work" would be seen as a reward for analysts, it is nevertheless true that people can become personally invested and willing to go the extra mile if they know their efforts will be appreciated and will make their routine work better.

Finally, the AF DCGS should develop a more formal process to gracefully offboard software tools that are no longer helpful. This will reduce the burden on training and some of the discovery problems that investigators face. Too many tools become obsolete or are no longer supported when their sole developer leaves. Handing off development in such cases should be considered an option; the Air Force should also be willing to let go of tools that no longer meet the need.

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[49] Detailed in Chapter 8 of Volume 2 (Menthe et al., 2021).

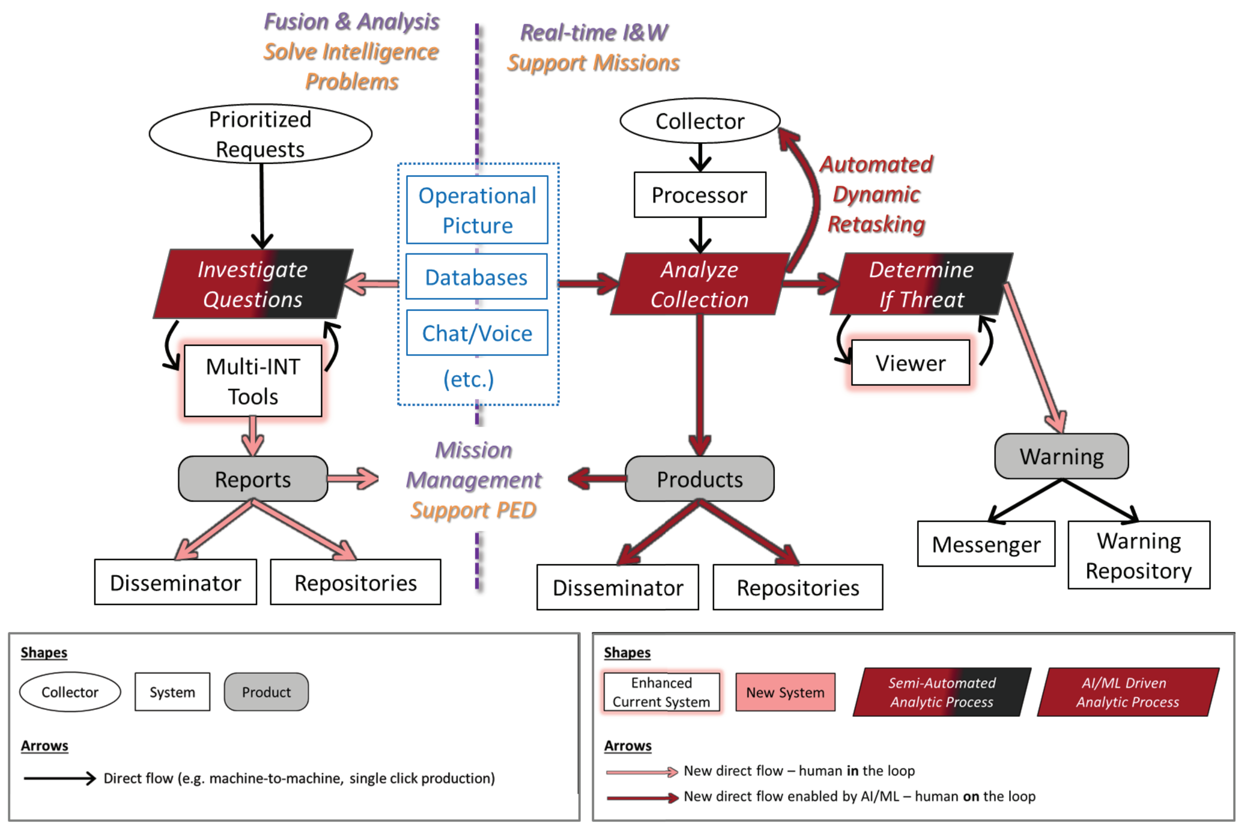
These recommendations should help foster a culture in which airmen are willing and able to try new things—a must if the AF DCGS is to realize the full benefits of AI/ML technologies.

Conclusions

The AF DCGS is at a crossroads. Technologies that can help address enduring analytic challenges are at last within sight or available today. The frantic tempo of demand experienced during Operation Iraqi Freedom and Operation Enduring Freedom has given way to steadier—although still substantial—demand, providing space for reflection and change. At the same time, the shift in national strategic focus from counterinsurgency and counterterrorism operations to more-capable peer competitors, such as Russia and China, presents new intelligence problems that will require greater integration and synthesis of information from many sources across widely varied theaters. This report suggests how AI/ML can help the AF DCGS meet these challenges and provides recommendations for a path for incorporating such technologies as they become available. A key point is that AI/ML technologies alone do not solve these challenges; rather, if properly implemented and complemented by human analysts with the right skills and training, they can allow the AF DCGS to evolve to better meet warfighter needs. Automation is best understood as a means to reshape human effort toward more productive ends, not to remove it entirely.

Figure 1.6 envisions the future AF DCGS data flow incorporating all the recommendations discussed in this report and in Volume 2. In this future, each of the competencies just discussed is addressed by a different team. On the right, the basic questions (who, what, when, and where) would be answered by AI/ML for all collections as they arrive, and human/machine teams would provide threat warning in a human-in-the-loop fashion. On the left, the advanced questions (how and why) would be answered as needed by human/machine teams to solve intelligence problems, fulfill requests for information, or support missions. On the bottom, we see that mission management would oversee both halves of the construct, tracking progress and developing tools and training appropriate to each. When they need to fuse information or perform additional analysis, human analysts would sift through AI/ML-tagged data in the cloud rather than manipulate data on arrival from the sensors. The cloud, and associated web-enabled tools, are represented by the light blue boxes in the center.

Figure 1.6. Generic Air Force Distributed Common Ground System Future Data-Flow Map



NOTE: The blue boxes represent optional sources that vary with specific circumstances. I&W = indications and warnings.

Instead of scaling the number of crews with the number of collectors, this construct would scale human effort with the number of supported units or requestors of information. This is a change from an input-scaled to an output-scaled structure. It is also a shift of human effort from analyzing everything "as collected" to providing additional analysis "on demand." This is a sustainable, scalable approach that makes better use of human capital by moving human effort down the spectrum of synthesis toward multi-INT and all-source analysis, facilitating nonlinear operations and wider sensor data fusion. This vision is consistent with the shift toward SIAS, and the step-by-step data-flow maps in Volume 2 show a workable path forward to get there. This is both consistent with and necessary to enable the AF DCGS to support an expanded future mission set.

Finally, although this project concerns improvements to AF DCGS processes, we note that the AF DCGS is part of the larger intelligence cycle. Inefficiencies elsewhere in this cycle can lead to suboptimal use of AF DCGS resources. The best analytic processes go to waste when investigators are asked the wrong questions or exploiters are tasked to examine the wrong things with inappropriate sensor methodologies. Analysts interviewed for this project said that they sometimes have difficulty understanding the reason behind an analysis request. It is to be expected that information needs will not always be precisely articulated or communicated in the fog of war or other intense situations. Although experienced analysts can and do substitute their own expertise to guess what is intended in the absence of clear requests, they are not mind readers. There is also the problem that many requesters simply cut-and-paste essential elements of information (EEI) from previous requests or submit requests that lack important cues and details (e.g., asking to report suspicious activity). Lack of understanding between analysts and requestors can also be a two-way street. EEI are sometimes poorly defined because the requestor does not fully understand how to best task and employ the systems in the first place, so they underuse their ISR resources and AF DCGS support. Although beyond the scope of this research project, we suggest that improvements in some of these areas may yield as high of a return on investment as the improvements we have recommended to the analytic process itself.

References

Air Combat Command Instruction 14-201, *Distributed Common Ground System (DCGS)–Intelligence Training*, Vol. 1, Joint Base Langley-Eustis, Va., February 5, 2018.

Alkire, Brien, Abbie Tingstad, Dale Benedetti, Amado Cordova, Irina Danescu, William Fry, D. Scott George, Lawrence M. Hanser, Lance Menthe, Erik Nemeth, David Ochmanek, Julia Pollak, Jessie Riposo, Timothy Smith, and Alexander Stephenson, *Leveraging the Past to Prepare for the Future of Air Force Intelligence Analysis*, Santa Monica, Calif.: RAND Corporation, RR-1330-AF, 2017. As of July 30, 2020: https://www.rand.org/pubs/research_reports/RR1330.html

Artetxe, Mikel, Gorka Labaka, Eneko Agirre, and Kyunghyun Cho, "Unsupervised Neural Machine Translation," paper presented at the Sixth International Conference on Learning Representations, Vancouver, Canada, April 30–May 3, 2018.

Cordova, Amado, Lindsay D. Millard, Lance Menthe, Robert A. Guffey, and Carl Rhodes, *Motion Imagery Processing and Exploitation (MIPE)*, Santa Monica, Calif.: RAND Corporation, RR-154-AF, 2013. As of July 1, 2020: https://www.rand.org/pubs/research_reports/RR154.html

Ephrat, Ariel, Inbar Mosseri, Oran Lang, Tali Dekel, Kevin Wilson, Avinatan Hassidim, William T. Freeman, and Michael Rubinstein, "Looking to Listen at the Cocktail Party: A Speaker-Independent Audio-Visual Model for Speech Separation," *ACM Transactions on Graphics*, Vol. 37, No. 4, Article 112, August 2018.

Frank, Robert H., and Ben S. Bernanke, *Principles of Microeconomics*, 3rd ed., New York: McGraw-Hill/Irwin, 2007.

Hannun, Awni, "Sequence Modeling with CTC," *Distill*, November 27, 2017. As of September 19, 2018: https://distill.pub/2017/ctc/

Irvine, John M., "National Imagery Interpretability Rating Scales (NIIRS): Overview and Methodology," in Wallace G. Fishell, *Optical Science, Engineering and Instrumentation '97, Airborne Reconnaissance XXI*, San Diego, Calif., July 27–August 1, 1997, Vol. 3128, November 21, 1997.

Krishnapriya, Kottakkal Sugathan, Kushal Vangara, Michael C. King, Vitor Albiero, and Kevin Bowyer, "Characterizing the Variability in Face Recognition Accuracy Relative to Race," *2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, Long Beach, Calif., June 16–17, 2019, pp. 2551–2566.

Liu, Yaqi, Xiaobin Zhu, Zianfeng Zhao, and Yun Cao, "Adversarial Learning for Constrained Image Splicing Detection and Localization Based on Atrous Convolution," *IEEE Transactions on Information Forensics and Security*, Vol. 14, No. 10, October 2019, pp. 2551–2566.

Losey, Stephen, "Air Force Announces Official Retirement Date for Iconic MQ-1 Predator Drone," *Air Force Times*, February 16, 2018. As of August 17, 2018: https://www.airforcetimes.com/news/your-air-force/2018/02/16/air-force-announces-official-retirement-date-for-iconic-mq-1-predator/

Menthe, Lance, Amado Cordova, Carl Rhodes, Rachel Costello, and Jeffrey Sullivan, *The Future of Air Force Motion Imagery Exploitation: Lessons from the Commercial World*, Santa Monica, Calif.: RAND Corporation, TR-1133-AF, 2012. As of June 30, 2020: https://www.rand.org/pubs/technical_reports/TR1133.html

Menthe, Lance, Amado Cordova, Elliot Axelband, Lindsay D. Millard, Abbie Tingstad, Endy Daehner, Kirsten M. Keller, and John Langley, *Technologies and Processes for Automating Processing, Exploitation, and Dissemination*, Santa Monica, Calif.: RAND Corporation, 2015, Not available to the general public.

Menthe, Lance, Dahlia Anne Goldfeld, Abbie Tingstad, Sherrill Lingel, Edward Geist, Donald Brunk, Amanda Wicker, Sarah Soliman, Balys Gintautas, Anne Stickells, and Amado Cordova, *Technology Innovation and the Future of Air Force Intelligence Analysis:* Volume 2, *Technical Analysis and Supporting Material*, Santa Monica, Calif.: RAND Corporation, RR-A341-2, 2021. As of November 24, 2020: https://www.rand.org/pubs/research_reports/RRA341-2.html

Menthe, Lance, Dahlia Anne Goldfeld, Abbie Tingstad, Sherrill Lingel, Edward Geist, Donald Brunk, Amanda Wicker, Sarah Soliman, Balys Gintautas, Anne Stickells, and Amado Cordova, *Technology Innovation and the Future of Air Force Intelligence Analysis:* Volume 3, *Technical Analysis of Data Flow Maps*, Santa Monica, Calif.: RAND Corporation, forthcoming, Not available to the general public.

National Public Radio, "Program Creates Computer-Generated Sports Stories," *All Things Considered*, January 10, 2010. As of August 21, 2018: https://www.npr.org/templates/story/story.php?storyId=122424166

Redmon, Joseph, Santosh Divvala, Ross Girshick, and Ali Farhadi, "You Only Look Once: Unified, Real-Time Object Detection," *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Las Vegas, Nev., 2016, pp. 779–788.

Riesbeck, Christopher K., and Roger C. Schank, eds., *Inside Computer Understanding: Five Programs Plus Miniatures*, Hillsdale, N.J.: Lawrence Erlbaum Associates, Inc., Publishers, 1981.

Specht, Donald F., "Applications of Probabilistic Neural Networks," in Steven K. Rogers, ed., *Applications of Artificial Neural Networks*, *Proceedings of the 1990 Technical Symposium on Optics, Electro-Optics, and Sensors*, Orlando, Fla., April 16–20, 1990, Vol. 1294, August 1, 1990.

Tingstad, Abbie, Dahlia Anne Goldfeld, Lance Menthe, Robert A. Guffey, Zachary Haldeman, Krista S. Langeland, Amado Cordova, Elizabeth M. Waina, and Balys Gintautas, *Assessing the Value of Intelligence Collected by U.S Air Force Airborne Intelligence, Surveillance, and Reconnaissance Platforms*, Santa Monica, Calif.: RAND Corporation, RR-2742-AF, forthcoming.

Tirpak, John A., "'PED Is Dead': ISR Roadmap Reaches Long for New Tech," *Air Force Magazine*, August 2, 2018. As of July 1, 2020: https://www.airforcemag.com/ped-is-dead-isr-roadmap-reaches-long-for-new-tech/

U.S. Air Force, "Air Force Distributed Common Ground System," webpage, October 13, 2015. As of August 16, 2018: https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104525/air-force-distributed-common-ground-system/

U.S. Air Force, *Next Generation ISR Dominance Flight Plan: 2018–2028*, Washington, D.C.: Congressional Research Service, R46389, July 24, 2018.

U.S. Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*, Washington, D.C., 2018. As of June 22, 2020: https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf

Whyte, Chelsea, "AI Created Images of Food Just by Reading the Recipes," *New Scientist*, January 10, 2019. As of June 30, 2020: https://www.newscientist.com/article/2190259-ai-created-images-of-food-just-by-reading-the-recipes/

RAND PROJECT AIR FORCE

There is growing demand for the Air Force Distributed Common Ground System (AF DCGS) to analyze sensor data. Getting the right intelligence to the right people at the right time is increasingly difficult as the amount of data grows and timelines shrink. The need to exploit all collections limits the ability of analysts to address higher-level intelligence problems. Current tools and databases do not facilitate access to needed information.

Air Force/A2 asked researchers at RAND Project AIR FORCE to analyze how new tools and technologies can help meet these demands, including how artificial intelligence (AI) and machine learning (ML) can be integrated into the analysis process. PAF assessed AF DCGS tools and processes, surveyed the state of the art in AI/ML methods, and examined best practices to encourage innovation and to incorporate new tools.

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