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AFRL GLOBAL PRESENCE STUDY

Daniel Miracle

AFRL/RX

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Final Report

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14. ABSTRACT ***(Maximum 200 words)***
The Air Force Research Laboratory (AFRL) mission is to lead the discovery, development and delivery of warfighting technologies for our air, space and cyberspace forces. To accomplish this mission, AFRL needs access to the best national and international research and development (R&D) and technical talent. The AFRL international portfolio and methods of engagement give good leverage of international R&D and talent, but there is concern that these approaches alone may be insufficient to access the growing fraction of research conducted overseas. In response, AFRL chartered this study to explore options that extend beyond the current AFRL overseas offices that scout and fund R&D, to establishing a strong physical presence within overseas laboratories. Based on the information obtained in this study, four major recommendation were made: They are 1) Do not build or lease physical overseas laboratory facilities' 2) Expand, simplify and fully utilize approaches to embed AFRL technical staff in overseas laboratories; 3) Conduct international, collaborative, residential R&D challenges; and 4) Do not pursue methods to influence international S&T funding.

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1. EXECUTIVE SUMMARY

The Air Force Research Laboratory (AFRL) mission is to lead the discovery, development and delivery of warfighting technologies for our air, space and cyberspace forces. To accomplish this mission, AFRL needs access to the best national and international research and development (R&D) and technical talent. The AFRL international portfolio and methods of engagement give good leverage of international R&D and talent, but there is concern that these approaches alone may be insufficient to access the growing fraction of research conducted overseas. In response, AFRL chartered this study to explore options that extend beyond the current AFRL overseas offices that scout and fund R&D, *to establishing a strong physical presence within overseas laboratories*. The study consisted of six tasks:

Task 1: Identify objectives for establishing a physical presence within overseas laboratories
Task 2: Document industry and university experiences with overseas laboratories
Task 3: Identify approaches to establish a physical presence within overseas laboratories
Task 4: Compare industry/university experiences with proposed objectives and approaches
Task 5: Evaluate functional requirements
Task 6: Recommendations

Task summaries are provided below. Task 4 results are included in Task 1-3 summaries.

1.1. Task 1: Identify objectives

A one-day workshop convened six AFRL senior leaders with broad experience in conducting R&D in both domestic and international domains to define the objectives for establishing a strong, physical AFRL presence within overseas laboratories. Three main objectives from this workshop were:

- Accelerate the development of AF-relevant technologies
- Expand the scope of AF-relevant technologies
- Build the competency and effectiveness of the AFRL workforce

These objectives are accomplished by more robust access to international talent and facilities, by leveraging overseas investments, and by embedding AFRL researchers in overseas centers of excellence. Industries and universities with overseas laboratories confirmed that access to talent and leveraging funding are top priorities, but their higher objectives diverged from the AFRL goals. Extensive industry and university experience with overseas laboratories confirmed that accelerating technology development comes by combining domestic capabilities with overseas resources and facilities and by harnessing the innovation and diversity of thought in overseas talent, not by 'working around the clock'.

1.2. Task 2: Document industry and university experiences with overseas laboratories

Telephone interviews were conducted with seven multi-national technology companies and two major universities to gather information regarding the motivations, benefits, challenges, risks, costs and lessons learned from operating overseas laboratories. An internet search also uncovered four overseas laboratories jointly operated with U.S. Government agencies. Seven common considerations for building and operating overseas laboratories were found in the interviews. Interview respondents also gave advice regarding Task 3 approaches to establish a strong physical presence within overseas laboratories. These insights were used to guide the development of concepts and the final recommendations.

1.3. Task 3: Identify approaches to establish a physical presence within overseas laboratories

There are many ways to establish a physical presence within overseas laboratories. A two-day workshop was held to develop ideas to reach this objective. Seventy-nine concepts were produced, and these were combined into 10 broad tactics that were then developed into four approaches:

- Approach A: Establish physical AFRL overseas facilities
- Approach B: Embed AFRL technical staff in overseas laboratories
- Approach C: Organize residential, collaborative R&D challenges
- Approach D: Strategically influence international science and technology (S&T) funding

1.3.1. Approach A

Approach A proposes to build or lease an overseas AFRL laboratory facility that is staffed primarily by local talent, with a small number of embedded AFRL technical staff. This fully utilizes overseas talent, demonstrates a long-term AFRL commitment, and gives AFRL more complete control over physical security than other options. This is by far the most costly option and it carries significant physical and information security risk. All Task 2 interviews indicated that AFRL should only consider building an overseas facility if there is a specific research need that is unavailable in the US.

1.3.2. Approach B

Approach B assigns AFRL researchers to work together with local technical staff in established overseas research facilities. Host institutions can be Government, university or industry laboratories. This approach is open to AFRL technical staff of any experience level and for durations that can range from weeks to years. This achieves all Task 1 objectives at significantly lower cost and risk compared to Approach A, and interview respondents agreed that this is a more efficient and cost effective approach. It is also more agile, with no fixed assets tethered to a specific country, and it provides a high degree of flexibility in assignments. Approach B includes four important enhancements to address limitations of existing international exchange programs: it provides AFRL funding for research conducted by local technical staff to deepen interactions with the embedded AFRL staff; it assigns either individuals or small teams of researchers; it allows AFRL to assign work objectives to the embedded AFRL staff (unlike the Engineering and Scientist Exchange Program, ESEP); and it identifies candidate countries, institutes and research topics through a periodic strategic AFRL-wide evaluation. The primary risk with this approach is the willingness of AFRL scientists and engineers (S&Es) to commit to a long-term overseas assignment.

1.3.3. Approach C

Approach C is inspired by a growing number of collaborative R&D challenges run by U.S. Government agencies. As major benefits, these challenges: expand the number of ideas developed by only paying for success; reach more deeply into the innovative talent pool; reduce risk by eliminating the need to predict at the proposal stage which team or approach is most likely to succeed; and deliver a specific research or technology result by a specified deadline. These are residential events to strengthen collaboration and are held overseas to better access international innovation and talent. The events can engage a single collaborative team or multiple teams that compete with each other. Through the University Nanosat Program initiated in 1999, AFRL is one of the first Government agencies to use this approach domestically. Sensitive technologies are a challenge due to difficulties in establishing intellectual property agreements and information security measures with the large number of countries and institutes involved in each challenge. Also, defense technologies in general and weapons technologies in particular may not inspire a high level of engagement from the international talent pool, limiting the number of opportunities addressed by these challenges. Task 2 found no industrial experience in organizing residential, collaborative R&D challenges.

1.3.4. Approach D

Approach D strives to influence overseas funding agencies to support science and technology (S&T) topics of strategic AF relevance by offering to jointly fund research projects. These opportunities could be identified through the AFRL overseas detachments operated by the Air Force Office of Scientific Research (AFOSR), and could be funded through an AFRL Venture Capital fund established to support this approach. This approach influences overseas funding decisions by reducing their risk and funding level, and it also gives AFRL a stake in the developed technology. Another approach is to negotiate the assignment of AFRL technical staff within overseas funding agencies. Funding agencies such as the National Science Foundation (NSF) and Defense Advanced Research Projects Agency (DARPA) commonly hire program officers from universities, industry or other Government agencies, but this may not commonly be done with overseas staff. Interview inputs from Task 2 revealed that industry and universities strive to obtain overseas funding, but do not attempt to influence funding provided to other proposers.

1.4. Task 5: Evaluate functional requirements

This task began by selecting approaches that are most likely to achieve the Task 1 objectives while minimizing cost and risk. All four approaches were briefed to the AFRL Commander and Executive Director. The cost and risk of Approach A were considered to be too high for the expected benefits and Approach D was expected to be difficult to implement with a low benefit – both were removed from further consideration. The policies, processes and authorities needed to implement Approach B and Approach C were evaluated by a team of functional professionals in this task. The functional domains included: personnel; finance and cost estimating; contracting; legal; foreign disclosure; and information security. It was found that the policies, processes and authorities needed to support Approach B and Approach C are not fundamentally different from those for existing international exchange programs. These methods are generally well-practiced within AFRL and no new barriers were found.

1.5. Task 6: Recommendations

Based on the information obtained in this study, four major recommendation were made:

- *Do not build or lease physical overseas laboratory facilities*
- *Expand, simplify and fully utilize approaches to embed AFRL technical staff in overseas laboratories*

- *Conduct international, collaborative, residential R&D challenges*
- *Do not pursue methods to influence international S&T funding*

These are consistent with the down-select decision made by the AFRL Commander and Executive Director, they are validated by industry and university experience in Task 2, and they fully support recommendations in the recent Air Force Science and Technology Strategy and the 2018 National Defense Strategy. Detailed suggestions for implementing these recommendations are provided in the body of this report.

During the course of this study, AFRL has already begun to implement some of the recommendations in Approach B by initiating two international exchange pilot programs (see Section 5.2.2).

2. INTRODUCTION

Global trends over the past 20 years have significantly changed how and where research and development (R&D) is performed in the world. In 1960, the U.S. accounted for 69% of the R&D conducted in the world [1]. This decreased to 40% in 2000 and has continued to shrink ever since (Figure 1). Scientific and engineering (S&E) talent is also increasingly found overseas. In 2018, nearly 60% of first university S&E degree awards (broadly equivalent to a bachelor's degree) were granted in China, India or the European Union; only 10% were granted in the U.S. [2].

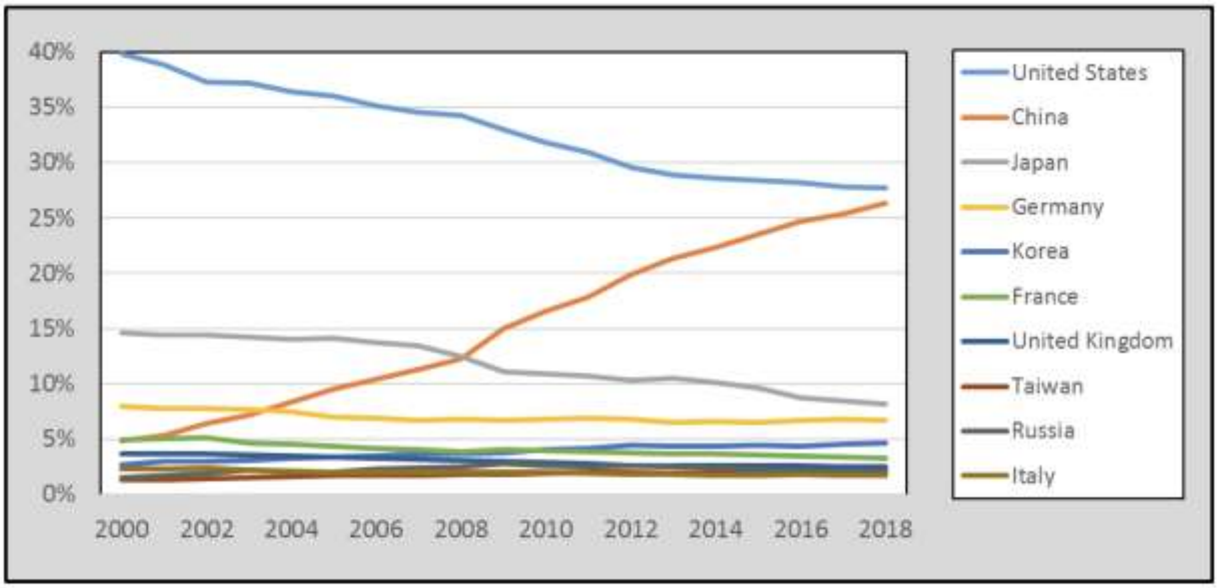

Figure 1. Share of global research and development (R&D) for selected countries, 2000 – 2018. Figure taken from [1].

The Air Force Research Laboratory (AFRL) leads the discovery, development and delivery of warfighting technologies for U.S. air, space and cyberspace forces. To accomplish this mission, AFRL needs access to the best national and international R&D and technical talent. International access is achieved through agreements, grants and personnel exchanges that are managed within AFRL through the International Plans and Programs office (AFRL/XPPI) and through the International Office of the Air Force Office of Scientific Research (AFOSR/IO). Through AFOSR, AFRL has overseas detachments in London, Tokyo and Santiago (Chile) to scout AFRL-relevant technologies and talent around the world. The approaches used to connect international science and technology (S&T) with the AFRL mission include Memoranda of Understanding (MOUs), Project Agreements (PAs), Data Exchange Agreements (DEAs), basic research grants, research initiatives, personnel exchanges, research sabbaticals for AFRL scientists, funding for site visits and conference support. In a typical year, AFRL operates over 60 different international agreements valued in excess of $1B. In addition, AFRL funds between 300-400 basic research grants in over 40 countries on five different continents, funds more than 150 overseas scientists to visit AFRL researchers in the U.S., and organizes multiple personnel exchanges. AFOSR funds a select number of overseas research initiatives to leverage international investments and talent – the U.S. Air Force-Taiwan Nanoscience Program was one example. This partnership between the Taiwan Ministry of Science and Technology (MOST) and AFRL focused on basic research in nanoscience and technology. In a seven-year period, this initiative produced over 250 research articles jointly published between U.S. and Taiwan scientists, demonstrating significant leveraging of overseas talent and resources.

While the current AFRL international portfolio and methods of engagement effectively leverage international R&D, there is growing concern that these approaches alone may be insufficient to adapt to the major global shifts discussed above. As a result, Air Force and Department of Defense (DoD) leadership are seeking new ways to provide better access to the growing pool of international R&D and technical talent. Inspired by another global trend – the formation of overseas laboratories by major, multi-national technology corporations – the question has been asked, "does it make sense for AFRL to have a physical presence within overseas laboratories?"

In response to these developments, AFRL chartered a study in June, 2019 to explore options for establishing a physical presence within overseas laboratories (Appendix A). AFRL already has an overseas presence through its many collaborative international agreements and funded research grants. AFRL also has a physical presence through the AFOSR detachments in London, Tokyo and Santiago, Chile. By considering approaches to establish *a physical presence within overseas laboratories*, this study explored options that include building and/or staffing a laboratory in an overseas location. The options explored in the study thus go beyond the approaches that AFRL currently uses to access overseas R&D and talent. This study supports the AF Science and Technology Strategy [3] and the National Defense Strategy [4]. The study consists of six tasks:

Task 1: Identify objectives for establishing a physical presence within overseas laboratories

Task 2: Document industry and university experiences with overseas laboratories

Task 3: Identify approaches to establish a physical presence within overseas laboratories

Task 4: Compare industry/university experiences with proposed objectives and approaches

Task 5: Evaluate functional requirements

Task 6: Recommendations

This is the final report for that study. The approaches and results from each of these Tasks are described in the following sections. Task 2 and Task 3 were conducted concurrently, the Tasks are presented in the order in which they were initiated. Task 2 results that were available at the time were used to inform discussions at the Task 3 workshop.

3. TASK 1: IDENTIFY OBJECTIVES

3.1. Approach

A workshop was held on 12 September 2019 to discuss the objectives for establishing a physical presence within overseas laboratories. The meeting included a small number of senior individuals with broad experience in conducting R&D in both domestic and international domains. The participants were introduced to the motivations for this study and the objective of the current task. The workshop was run as a free-flowing discussion of ideas and questions. Notes were taken real-time and projected on a screen to focus the discussion and to build a common understanding. Immediately after the workshop, these notes were critically evaluated and revised to draw out the main concepts that were most likely to impact the AFRL mission. A draft of these objectives was subsequently distributed to the workshop participants for final comments. The workshop participants are listed in Appendix B, and the results of this process are given below.

3.2. Results

The final list of objectives for establishing a physical presence within overseas laboratories is given in Figure 2. The three main benefits are: accelerating the development of AF-relevant technologies; expanding the scope of AF-relevant technologies; and building the competency and effectiveness of the AFRL workforce. These are each discussed below. The possibility of influencing foreign military sales was discussed as a potential benefit of establishing a physical overseas laboratory presence but was not considered to be a major motivation for AFRL. Similarly, access to a low-cost workforce was found to be a benefit for many industries but was not considered of significant value to AFRL.

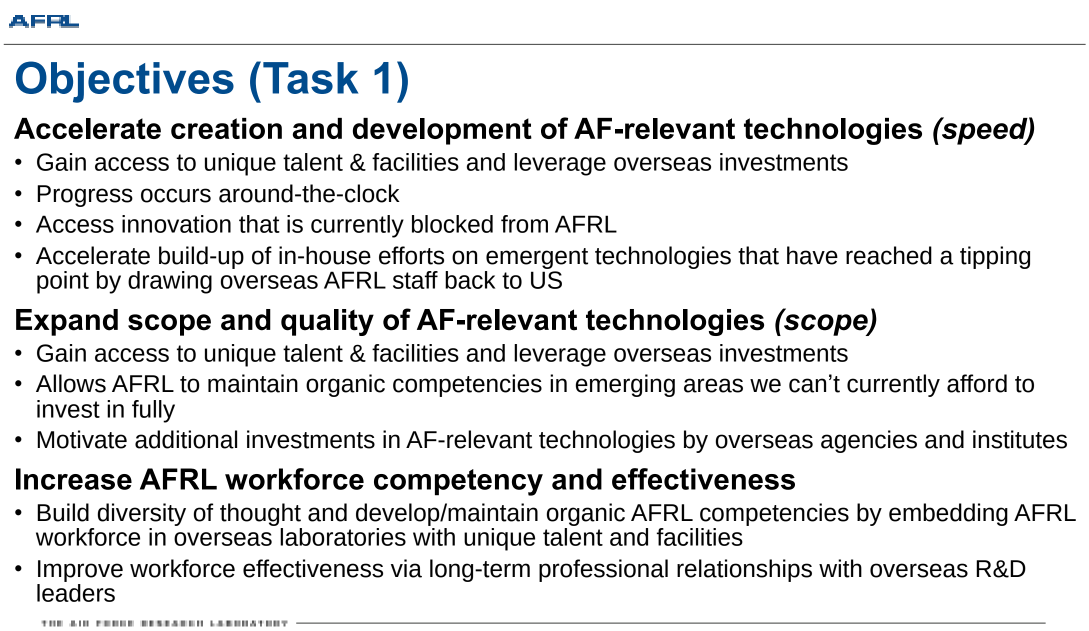

Figure 2. Results of Task 1: Identify objectives for establishing a physical presence within overseas laboratories.

3.2.1. Accelerate creation and development of AF-relevant technologies

The workshop addressed the theme of accelerating R&D as central to achieving the AFRL mission. Basic science ("creation") and applied technology ("development") are both included in this benefit, as was the ability to accelerate AFRL R&D by leveraging overseas funding and by accessing relevant talent and facilities.

Overseas R&D investments can come from science foundations similar to the U.S. National Science Foundation (NSF); for example in the United Kingdom (U.K.) this is the Engineering and Physical Sciences Research Council (EPSRC). Funding may also come from overseas Government agencies, such as the Ministry of Science and Technology (MOST) in Taiwan or the Ministry of Defence (MoD) in the U.K. Finally, overseas universities and industries make investments in R&D that could be leveraged to quicken the pace of AFRL technology development. AFRL leverages Government funding from other countries through Project Agreements (PAs), and less frequently through international S&T initiatives. These represent a restricted range of the full potential, and establishing a physical presence within overseas laboratories may broaden the scope of opportunities.

The current AFRL portfolio gives limited access to the growing pool of international talent and innovation. Project Agreements only give access to foreign Government researchers, and while the number of overseas university and industry research grants executed annually is large (300-400), these generally represent part-time efforts over a year or less. AFRL currently has no approaches to employ foreign talent full-time over extended periods. Several models for establishing a physical overseas laboratory presence give opportunities to tap into this resource.

Unique R&D facilities may be available at overseas universities, Government laboratories, international industrial R&D centers or international research centers jointly operated by a consortium of countries such as the International Thermonuclear Experimental Reactor (ITER, see Figure 3). Access to these unique facilities may be a feature of some approaches for establishing a physical presence within overseas laboratories, for example sending AFRL S&Es to conduct research at already established institutes. However, this benefit is not expected for other models, such as building AFRL-specific brick-and-mortar laboratory facilities.

The concept of working 'around the clock' by coordinating domestic research with efforts in an overseas laboratory seemed to have some appeal in the Task 1 workshop discussions, and is listed as a motivation for accelerating R&D in Figure 2. However, this was not a motivation for overseas industrial R&D laboratories, and is discussed in Task 4.

A final concept discussed at the workshop was to accelerate the establishment of an AFRL competency by embedding AFRL technical staff in overseas centers of excellence. Consider an emergent technology that may eventually develop strategic value, but for which AFRL currently doesn't have a major competency. Establishing a world-class competency typically requires a critical mass of trained researchers, funding and facilities over a period of time. In an emergent topic, where it's not yet certain if the field will develop, this represents a significant investment risk for staff, facilities and funding. *This risk can be reduced by embedding AFRL researchers in an existing overseas center of excellence as the topic develops.* These researchers gain knowledge and experience and can return to the U.S. to build a new domestic AFRL competency quickly if and when the topic reaches a point of strategic value.

3.2.2. Expand scope and quality of AF-relevant technologies

The ability to leverage overseas funding and to access relevant talent and facilities not only can accelerate the creation and development of AF-relevant R&D, but it can also expand the scope and quality of research within the AFRL portfolio. This is thus the first sub-bullet on both the ‘speed’ and ‘scope’ objectives in Figure 2. Embedding AFRL researchers in overseas centers of excellence similarly can both accelerate R&D and also expand the scope of research in the AFRL portfolio. The workshop participants also felt that embedding AFRL researchers in overseas institutes could potentially influence the investments made toward topics of AF relevance. It was recognized that this is a delicate matter and that it is difficult to imagine an overseas funding agency allowing a foreign researcher to direct funding on topics of strategic value. Nevertheless, the opportunity to exert an indirect influence toward topics of mutual interest was felt worthy of consideration by workshop participants.

3.2.3. Increase AFRL workforce competency and effectiveness

Several concepts for establishing a physical presence within overseas laboratories involves embedding AFRL researchers in foreign institutes. This builds diversity of thought by exposing AFRL researchers to others with different backgrounds, educations and approaches to solving difficult problems. This diversity of thought is generally accepted to improve workforce competency and effectiveness. This also enables AFRL researchers to form long-term, professional relationships with other scientists who may develop as leaders in their fields and in their countries, thus building a robust international professional network that is an essential asset to achieving the AFRL mission.

4. TASK 2: DOCUMENT INDUSTRY AND UNIVERSITY EXPERIENCES WITH OVERSEAS LABORATORIES

Within the U.S., a growing fraction of R&D is done with industrial funding. Over half of the applied research and over 85% of technology development in the U.S. was funded by industry in 2018, with a total aggregate fraction of nearly 70% [5]. In the past two decades, many U.S. industries have established overseas laboratories to perform a growing fraction of this R&D. Following this trend, universities and a small number of U.S. Government agencies have also formed or partnered with overseas facilities. This study sought to learn from the motivations and experiences of some of these institutions to guide AFRL considerations.

4.1. Approach

Toffler Associates conducted an internet search to identify a representative sampling of U.S. corporations, universities and Government agencies with a physical presence at overseas laboratories. They reviewed 170 internet documents, identifying 17 major U.S. companies, universities, and Government agencies with physical overseas research facilities. Toffler Associates scheduled telephone interviews with nine of these organizations, including two universities, two global technology companies, a leading information technology (IT) corporation and four major defense contractors. The organizations with which interviews were held are listed in Appendix B. The telephone interviews included over 18 senior organizational leaders. The purpose of the telephone interviews was to gather information regarding the motivations, benefits, challenges, risks, costs and lessons learned from having overseas facilities. To ensure maximum openness, specific comments from the interviews were not attributed to the company that made them. The telephone interviews typically lasted for one hour. Notes taken during the interviews were compiled and analyzed for common insights and trends, and major findings were compared with the objectives (Task 1) and the recommended approaches (Task 3) determined in parallel in this study. The results of the online search and the interviews are provided below.

4.2. Results

Information for Government agencies with overseas laboratories was obtained through publicly available sources and interviews were not held, so that the agencies and the overseas facilities can be listed by name. Further, only a limited number of agency-sponsored overseas laboratories were found. The results for overseas laboratories established by U.S. agencies are thus listed separately. This is followed by the interview results describing the common characteristics identified for overseas laboratories.

4.2.1. Government agencies

Four overseas laboratories that are jointly operated with U.S. Government agencies (DoD, Department of Energy (DoE) and the National Aeronautics and Space Administration (NASA)) were found during the internet search of this study (Figure 3). None of the laboratories are wholly owned by the U.S. agency, and all four are staffed by a blend of international and U.S. researchers. Three of these global institutes were formed long before the current trend of U.S. organizations establishing overseas research laboratories, and a clear geographic motivation exists for each of these three facilities. The two DoD overseas institutes (AFRIMS and USRAMU-K) are global, subordinate units of the Walter Reed Army Institute of Research [6].

AFRL

Some U.S. Agencies with Overseas Labs

ARMED FORCES RESEARCH INSTITUTE OF MEDICAL SCIENCES (AFRIMS)	NASA DEEP SPACE NETWORK (DSN)	U.S. ARMY MEDICAL RESEARCH UNIT-KENYA (USRAMU-K)	DOE INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)
• Located in Bangkok, AFRIMS conducts "state of the art medical research and disease surveillance to develop and evaluate medical products, vaccines, and diagnostics to protect DOD personnel from infectious disease threats—many of which also endanger the men, women and children of Southeast Asia." • AFRIMS was established in 1959.	• Conducts earth orbit and astronomy missions while engaging in research in radio astronomy. • The three locations – Australia, Spain, and US – ensure that a spacecraft is always in contact at least one substation. • Each lab employs their nationals but also includes international staff. • The NASA DSN is run by the Jet Propulsion Laboratory (JPL) and was officially launched in 1963	• Located in Nairobi, the Unit researches emerging infectious diseases and focuses on programs that encompass HIV prevention and treatment. • The unit was provisionally established in 1969 and permanently established in 1973.	• ITER is a joint international experiment between the US, China, EU, India, Japan, Korea, and Russia that seeks to develop fusion energy using a toroidal chamber with magnetic coils (tokamak). • US scientists and engineers work in EU & Korea facilities. • All ITER facilities coordinate and share research. • The US portion of ITER is managed by the Department of Energy (DOE) thru the Oak Ridge National Laboratory (ORNL). • ITER was formed in 2007

THE AIR FORCE RESEARCH LABORATORY

Figure 3. Selected overseas laboratories that are jointly operated with U.S. agencies.

Foreign governments also utilize shared laboratories to gain access to unique or costly facilities. Two well-known examples include the International Thermonuclear Experimental Reactor (ITER, Figure 3) and the European Organization for Nuclear Research (commonly known as CERN). ITER is funded and run by seven member entities – the European Union, Indian, Japan, China, Russia, South Korea and the U.S. ITER is a research and engineering megaproject consisting of the world's largest magnetic confinement plasma physics experiment to study and develop a tokamak nuclear fusion reactor for energy production. CERN operates the world's largest particle physics laboratory to study the basic laws governing interactions between elementary particles, the deep structure of space and time, and the relationships between quantum mechanics and general relativity. In addition to such shared facilities, other Five-Eyes countries also use rotational assignments as a means to collaborate with researchers and institutes beyond their borders.

4.2.2. Common considerations for establishing overseas industry and university laboratories

The telephone interviews identified seven common considerations for forming overseas industry and university R&D facilities (Figure 4). First, all nine organizations interviewed said that *overseas laboratories are created to address a clearly defined need*. Common needs include: (i) access to talent not available in the U.S.; (ii) access to lower-cost talent; (iii) access to international markets; (iv) access to international funding; (v) relationships with universities, other companies, or other countries; and (vi) enhancement of organizational brand. Three of these motivations are not likely to be important for AFRL (access to lower cost talent, access to international markets, enhancement of organizational brand). The other three reasons were all identified in Task 1 and Task 3 of this study.

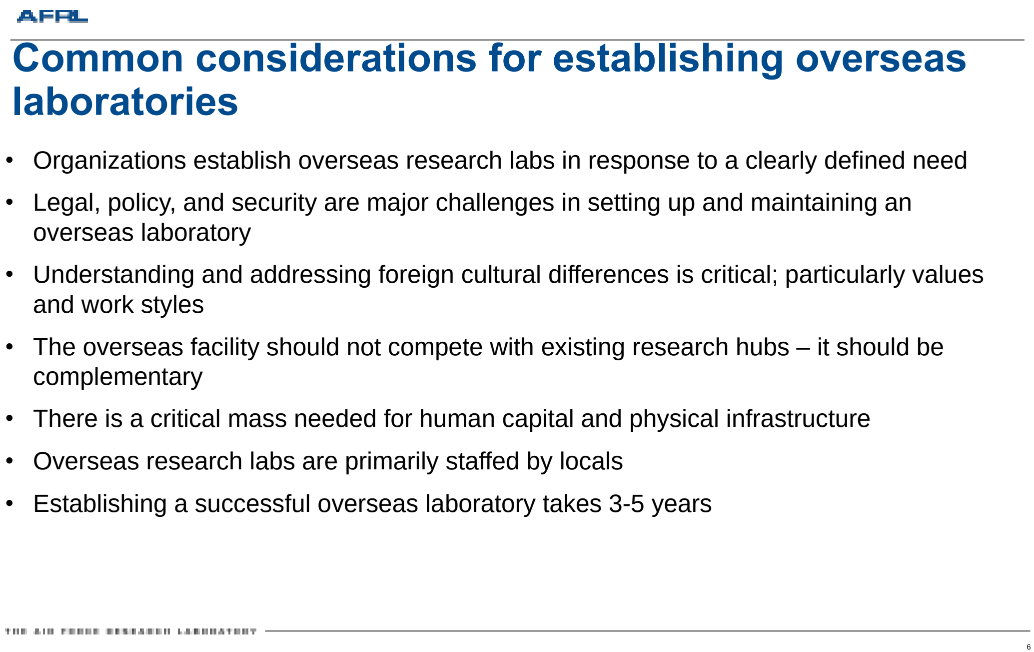

Figure 4. Common considerations for establishing overseas industry and university laboratories identified from Task 2 interviews.

The second common factor is that *legal, policy, and security considerations offer major challenges* in setting up and maintaining an overseas laboratory. All organizations interviewed stated that conflicting laws and policies between U.S. and foreign countries make it difficult to set up a laboratory, and that learning and adapting to foreign workplace laws and Human Resources (HR) policies were the most difficult and time-consuming challenges. Understanding the regulations and laws at a level needed to reach full productivity sometimes took years. Some countries offer lower barriers than others, and four of the nine organizations indicated that smaller or less westernized countries were easier to work with than major western countries such as Germany, Spain and the United Kingdom (U.K.), which had more time-consuming bureaucratic requirements. Protecting proprietary information and intellectual property (IP) was also a challenge, and the defense contractors all said that the ability to do classified work was difficult due to limited secure facilities, International Traffic in Arms Regulations (ITAR), Trade Agreement Acts (TAAs) and technology control plans.

Understanding and addressing foreign cultural differences is the third common requirement for establishing overseas laboratories. All nine organizations indicated that cultural differences are complex and are a key challenge in standing up and running an overseas lab, particularly values, attitudes, employee expectations and work styles. As two examples, many foreign workers display a cultural hesitancy to challenge authority, and the number of hours worked per year can vary by 10-15% or more in different regions of the world. Different cultures also have different perspectives on what is protected IP and what is not. Understanding and respecting local customs and culture are needed to build trust with employees and with the host country, and this trust is essential to the overall success of the laboratory. Additional management oversight and training is needed to clarify expectations and ensure performance so that the best capabilities of a foreign workforce are realized. Of particular relevance to AFRL, several contractors indicated that some foreign workers or organizations may not want to work with a U.S. military organization.

The fourth consideration is that *overseas facilities should not compete with existing research hubs – they should be complementary*. The overseas laboratory must not only be distinct from other labs that exist domestically within the organization, but they must also not duplicate capabilities that are already established within the host country. In one interview, it was specifically stated that the host country would likely be upset if the U.S. opened a lab that competed with local government or corporate labs, but that co-locating with a foreign government lab and jointly funding programs would be welcomed. Four of nine organizations interviewed said that the physical facility should support or benefit the host country and its people and that clear relationships with existing facilities should be established.

A critical mass is needed for human capital and physical infrastructure – this is the fifth insight from the interviews. As a general consensus among interview participants, a technical staff in the range of 20-30 constituted a critical mass. Six of nine organizations also said that an adequate in-country infrastructure of management oversight, IT support, HR, lab space and physical security was important for a properly functioning team. The sixth consensus among the interviews was that *overseas research labs are primarily staffed by local talent*. This view was unanimous and it is embedded in two of the comments already discussed.

Finally, all respondents agreed that *it takes years to establish a successful foreign laboratory*. Most organizations indicated it took three to five years to establish a physical lab in a foreign country. For some major corporations it still took one to two years to stand-up a lab even when they had a clear strategy and an experienced stand-up team, and in some cases, false starts added to that timeframe significantly. One industry said, “We had relationships with universities and appropriate government entities, and a team on the ground in [host country] two years before opening our location.” This lead-time requires continuity of purpose and support during changing organizational priorities and leadership.

5. TASK 3: IDENTIFY APPROACHES TO ESTABLISH A PHYSICAL PRESENCE WITHIN OVERSEAS LABORATORIES

5.1. Approach

There are many ways to establish a physical presence within overseas laboratories. A two-day workshop was held at the Wright Brothers Institute TeĉEdge facility on 16, 17 October 2019 to generate and develop ideas for accomplishing this objective. Eleven workshop participants with direct personal experiences in conducting international collaborative research were drawn from six different AFRL Technology Directorates. The team was encouraged to think freely for innovative approaches with no constraints. The workshop was facilitated by staff from Toffler Associates, who has experience in conducting such events. The workshop participants are listed in Appendix B.

By challenging the group to consider how research might be conducted in the year 2040, a large number of concepts was generated from individual insights and group interactions in the 'divergent thinking' part of the workshop. The group produced a smaller number of approaches in the 'convergent thinking' phase by combining similar or complementary concepts. The group evaluated the tactics against the objectives identified in Task 1 to define approaches most likely to give the desired benefits. Discussions considered the level of research (basic or applied) appropriate for each tactic as well as anticipated costs and risks associated with staffing, facilities, security and intellectual property. Anticipated benefits and costs were weighed against those expected for a similar domestic R&D investment. This analysis refined the initial set of tactics into a short list of approaches. In addition to developing new approaches, suggested improvements to existing programs and processes for international collaboration were identified. The results from Task 3 are described below.

5.2. Results

The 'divergent thinking' brainstorming session produced a list of 79 concepts to achieve the objectives from Task 1 that were subsequently combined into 10 broad tactics (Table 1). These concepts and tactics were refined into more detailed approaches to produce four recommended approaches that are discussed in the following subsections.

Table 1. Concepts and tactics for establishing a physical overseas laboratory presence.

Tactic	Concept
New Facilities	Establish labs so always on - when one goes to sleep one is just starting - follow the sun
	Co-build facility with foreign entity or government (Approach A)*
	Create duplicate labs so can seamlessly work between locations (Approach A)*
	Create joint overseas microelectronics foundries (Approach A)*
	Create international software development center (Approach A)*
	Create Global Basic Research Lab (GBRL) and place AFRL staff onsite (Approach B)*
	Create a mobile or transportable lab
	Rent overseas facility to house our equipment for foreign use (jointly staffed) (Approach A)*
	Set up international center of excellence - AFRL funds facility, invites others to bring equipment, we all work together (Approach A)*
	Create common lab that can be cost-shared
New Programs or Processes	AF Venture fund
	Ghost writers - outsource writing to lower cost resources
	Have multi-shifts domestically for 24x7
	International crowd sourcing or world competitions (Approach C)*
	Host domestic reverse engineering hackathons (Approach C)*
	Expand scope/flexibility of existing international programs - (WOW, ESEP) - make better use of what we have (Approach C)*
	WOW Part 1: AFRL research works with their team and when researcher comes back, brings back fellow research partner (both sides understand and extends relationship)
	Establish a panel to identify/provide strategic direction on events and conferences where AFRL needs to have a presence based on topic area or who will be attending and or speaking
AFRL Employees Overseas	Embed AFRL researchers at overseas USAF base (Approach B)*
	Embed AFRL researcher at overseas lab (Approach B)*
	Embed AFRL researcher at overseas university, multi-year (Approach B)*
	AFRL employee teaches overseas with a research team
	Put AFRL researchers in countries to build relationships and have an ear to the ground, a 1-person XOARD looking @ all TRLs (like ONR-G)
	Long term assignments (>1 year) of AFRL researchers overseas (Approach B)*
	Embed researcher (operational level) with joint military groups
	Senior AFRL researcher goes overseas to establish network, junior team cultivates and builds on this relationship
	Expand XOARD offices in new countries - rapidly stand up and shut down
	Send (Junior) LTFT researchers to work in industry as first assignment (could be first job or to get degree)
	Partner with international funding agency - AFRL researcher works in the funding agency, gets insight into topics and funds topics of interest (Approach D)*
	Embed AFRL S&E in overseas center of excellence (university, government, corporation) where AFRL can't afford to invest in a critical mass effort to develop AFRL organic competency for potential future growth (Approach B)*
Foreign Talent in the US	Allow foreign students in US to collaborate with AFRL in the US and potentially be hired
	Fast track VISA/Citizenship for foreign talent so they come work in the US
	Bring international researchers to USAF facilities (research)
	Bring international faculty to US (fellowship)
	Hire foreign nationals as AFRL employees
Collaboration Tools and Access	Establish communication channels to share what's happening overseas (everybody stays in home country)
	Virtual Window on Science (WOS – visit to AFRL by foreign researcher)
	Provide better tools to better communicate with fellow collaborators - both here and with international researchers (e.g., communication tools to include high volume data exchange)
	Provide common project coordination via video teleconferencing meetings - could be university or government lab
	Virtual collaboration space on international servers - GitHub, data mining
	Establish virtual SME group/consortium or particular topics
	Remote lab with virtual access to facilities such as microscopes, beamline
	Reduce barriers to data search (e.g., foreign journals)
	Use NASIC more systematically and broadly to access information that's currently blocked

Better Access to Data	Participate more openly in technical information exchanges with overseas entities
	Collaborative reports or papers
	Open access journal for DOD research (free)
International Partnerships	Joint CERN-like facility
	Use overseas computational infrastructure
	Take advantage of unique overseas technical capabilities we currently don't have access to (Approach B,C)*
	Work with embassies - information exchanges, relationships to better understand what is going on
	Research-cations - communal "camp-like" experiences => Gordon conference or Kavli Institute on steroids in foreign countries, cultural immersion (Approach C)*
	Encourage partnerships, engagements with professional societies (international and domestic)
Fund Overseas Program	Expand EOARD & AOARD & SOARD program to include 3-yr grants for international universities (Approach B)*
	AFRL sponsors university lab overseas (Approach B)*
	Co-invest in international R&D or provide government subsidies to bring raw materials or manufacturing to the US
	Fund universities to create short courses on topics of interest
Miscellaneous	Use overseas reviewers for funding proposals & vice versa (and decision making program)
	Take online courses/teach online courses internationally => When teaching internationally, promote awareness
	Co-locate with others - if we have space, invite researchers to come work with us (free rent)
	Create international roadmap for technologies
	Establish dual-credentialing - as international adjunct professor, can get funds from multiple groups (industry & Govt)
	Provide offset/share high TRL tech for international organization's investment (FMS)
	International EOARD/AOARD grants coupled with lab activity (build proposal at start with international partners) - forward thinking joint proposals
	Lend equipment to foreign entities and we get access to the resulting data (and vice versa)
	Build sister site for unique facilities to bring back best practices (AFRL researcher must go overseas but then duplicates lab set up upon return)
Process and Program Improvements	Reduce barrier to higher TRL with non-defense entities (INTL)
	Break down financing/process barriers - Process overhaul for international exchanges
	Embed AFRL researchers in critical mass overseas - funding spans OCONUS & CONUS multi-year (Approach B)*
	Utilize bi-lateral PA's with funding for collaborative research (money doesn't change hands)
	Expand SBIR/STTR internationally
	Expand current MURI to include international partners
	Leverage cultural indoctrination program (e.g., SOCOM)
	Enhance government - industry talent exchanges (longer term) - Do it internationally (e.g., Google in London)
	Enhance adjunct status and thesis committees - encourage it more
	Find and hire better talent (US & foreign) - more targeting scouting and active recruiting
	Make it easier to attend more international conferences and take more international courses
	International LUCI (Lab-university collaboration initiative)
	Establish long term funding source for cultivating international relationships

* Concepts that are included in one of the four recommended approaches are indicated

5.2.1. Approach A: Establish physical AFRL overseas facilities

The first approach considered, establishing an AFRL overseas laboratory facility, is described in Figure 5. In the extreme case, AFRL bears all cost for building, operating and maintaining the facility, but it may also be shared with an overseas partner which could include a foreign government, a university, or industry. This approach addresses all three of the goals from Task 1 (Figure 2). This approach fully utilizes overseas talent, a major motivation for establishing a more robust overseas presence. However, some staffing with AFRL employees is needed to achieve the third objective (improved AFRL workforce development). This approach demonstrates a long-term AFRL commitment, opening opportunities for access to overseas funding and talent that might not be available otherwise. This approach gives AFRL more complete control over physical security than other options, but this nevertheless represents a significant security risk due to the overseas location.

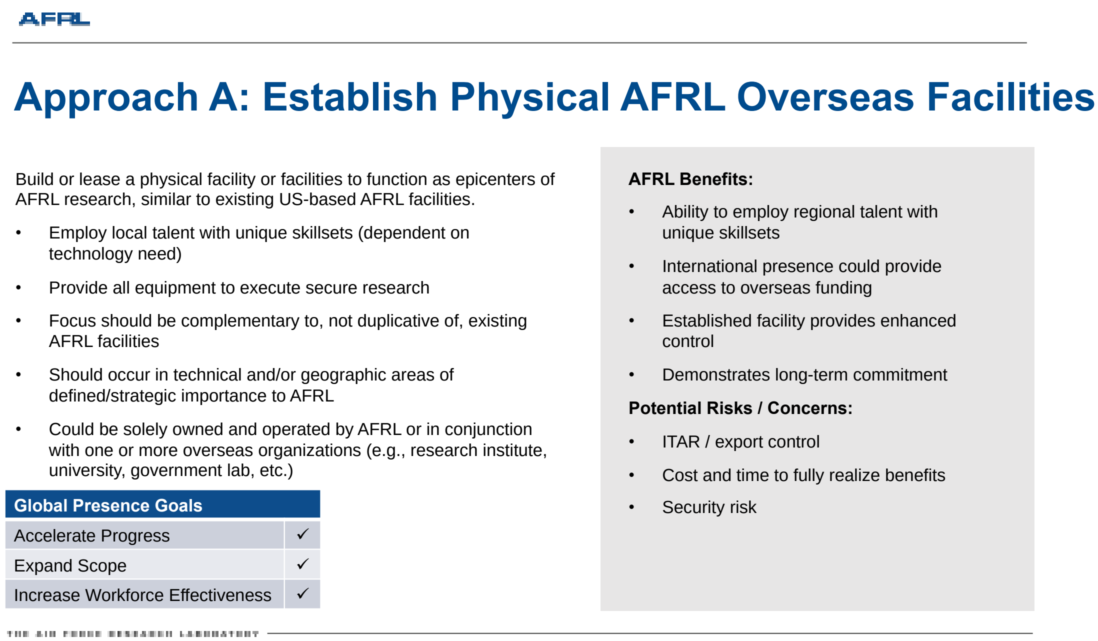

Figure 5. Approach A Characteristics of establishing a physical AFRL overseas facility.

This is by far the most costly option identified in this study. In addition to the cost of building, maintaining and operating the facilities, AFRL also will require additional functional staff who are competent in both U.S. Government and overseas policies and laws regarding human resources, contracts, business practices and local customs. This requires significant additional overhead to the AFRL enterprise. As an additional constraint, lessons from Task 2 suggest that the R&D conducted at the overseas facility should not duplicate or compete with existing AFRL programs or capabilities. This tactic is most appropriate for conducting basic research, since a strong reliance on foreign talent makes it difficult to emphasize applied research, especially for strategic or critical technologies. Additional requirements and issues to be addressed with the formation of a physical overseas laboratory are discussed in Task 2.

5.2.2. Approach B: Embed AFRL technical staff in overseas laboratories

The second option identified in the workshop is to embed AFRL technical staff in established overseas research facilities (Figure 6). The host R&D facility could be 'behind the fence' at a foreign Government R&D facility, or it could be at a foreign university, national laboratory or industry site. This approach addresses all three objectives from Task 1 and aligns with the AF Science and Technology Strategy [3]. Foreign talent accelerates progress and expands the scope of AFRL research not by hiring them, but by conducting R&D with them as partners and collaborators within their home institute. Significant benefits to the AFRL workforce are expected by transferring knowledge and experience from experts in the chosen field while retaining the ability to recall AFRL staff.

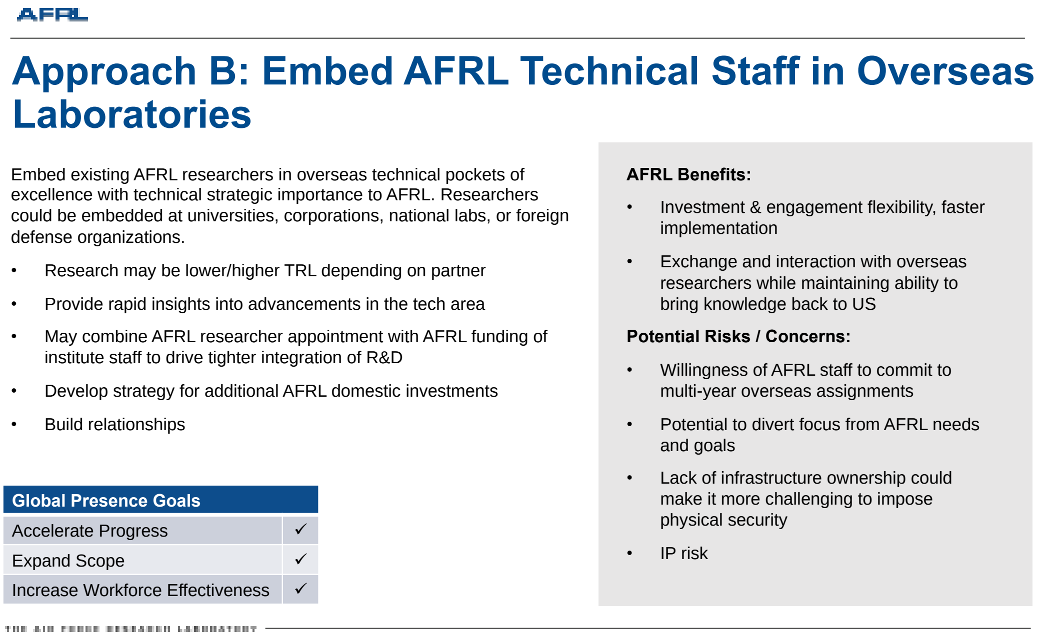

Figure 6. Approach B Characteristics of embedding AFRL technical staff in overseas laboratories.

To be most effective, this approach requires a strategic evaluation of overseas investments and centers of excellence that overlap with AFRL strategic needs and address AFRL technology gaps. Such an evaluation is currently done annually within AFRL as part of the 'Lead/ Leverage/ Watch' evaluation of domestic and international research. After identifying an overseas center of excellence, an agreement of mutual benefit must be developed with the host institute. One idea discussed at the workshop was to combine the AFRL appointment(s) with a complementary research grant or contract to the host institution. This provides all of the resources needed to ensure a tight and focused technical interaction that is more robust than a typical in-kind collaboration. This concept was advocated at AFOSR some years ago as the Global Basic Research Laboratory (GBRL), but was not pursued due to turnover in AFOSR leadership.

AFRL programs are already available for embedding researchers in overseas institutes but they have important limitations. The AFOSR Window on the World (WOW) program offers AFRL researchers overseas assignments to non-Government laboratories for no more than 179 days. The Engineering and Scientist Exchange Program (ESEP) is a DoD program that places AFRL researchers for 2 to 3 years at a foreign Government facility. ESEP assignments require an official Memorandum of Understanding (MOU) with the host country. The approval process is lengthy and rather cumbersome, and ESEP personnel are assigned duties by the host institute, not AFRL. *There are currently no programs for placing AFRL scientists and engineers in non-Government laboratories for more than 179 days, this is a serious gap.* None of the available programs combine funding of staff at the host institute with the AFRL appointment, limiting the scope and depth of interactions to, at best, what can be achieved with an in-kind collaboration. WOW and ESEP candidates generally self-nominate or are advocated by local management such as a first-level supervisor or a Branch Chief and there is no mechanism to align assignments with AFRL strategic objectives. Other gaps in overseas temporary placement capabilities are being addressed through AFRL pilot programs motivated by the AF Science and Technology Strategy [3]. The AFRL Short Term Exchange Program (STEP) places AFRL researchers in overseas

Government laboratories for up to 179 days and the AFRL Innovative Teaming Exchange (ITEx) sends small, highly specialized technical teams to work in Government labs for up to 1 year. The AFRL pilot programs are limited to DR-02 civilian (STEP and ITEx) and active military within the ranks of First Lieutenant to Major (STEP).

Approach B has a much lower cost and is more agile than Approach A, and it provides important benefits beyond existing AFRL programs. *This approach has no specific limits on duration of the overseas assignment and no restrictions on the type of laboratory where the AFRL researcher is embedded (university, Government, industry), providing maximum flexibility for the range of overseas opportunities available.* Beyond a minimum competency and time in service, this approach has no restrictions on the civilian grade or military rank of the AFRL participant. Like the ITEx AFRL pilot program, Approach B specifically includes the ability for single investigator assignments as well as small teams of researchers. Since the approval process resides fully within AFRL and the Air Force Materiel Command (AFMC), it can be faster and more responsive than the ESEP program, which involves several layers of approval outside AFRL. This proposed approach provides better alignment with AFRL strategic priorities by identifying the most impactful opportunities through the Lead/ Leverage/ Watch analysis conducted as part of the annual AFRL investment strategy. Combining funding to the host institute with the AFRL assignment is a particular strength of the approach proposed here. Finally, unlike the ESEP program, AFRL retains the ability to assign work duties that best align with Air Force priorities.

Opportunities to pursue this suggested approach have recently been identified in response to the growing awareness of the value of more robust engagements with strategically selected overseas partners. The Korean Institute of Basic Science is a collaboration of 31 academic, industry, and government institutes, each funded at $100M (U.S. dollars) by the Korean Government with matching industry funds from Samsung and Hyundai. All of the technical universities in this Institute teach in English, reducing barriers for embedded AFRL technical staff. On a recent visit by Col. D. Brent Morris (AFOSR/IO), leadership of the Korean Institute of Basic Science was enthusiastic about the possibility of collaborating further with AFRL and embedding AFRL personnel at their basic science institute. As a second opportunity, the Defence Science and Technology Laboratory ([dstl]) of the U.K., a long-standing strategic AFRL partner, has recently offered to embed a small team of AFRL researchers at their Porton Down facility. By modifying existing policies to allow team assignments, the AFRL ITEx pilot program was initiated in response to this request. Plans are currently underway to accept the [dstl] offer and to test this pilot program. While ITEx overcomes one important limitation by enabling the temporary placement of a small team of researchers, gaps remains through the inability of AFRL to assign the work duties to the AFRL employees during the overseas assignment and to open this opportunity to the full range of AFRL S&E experience levels.

The primary risks associated with this approach include the willingness of AFRL S&Es to commit to a long-term, overseas assignment. This is a barrier to the more widespread use of current overseas programs. AFRL will not have ownership of the physical facilities; this could increase the risk of information control with this approach.

5.2.3. Approach C: Organize residential, collaborative R&D challenges

The third concept developed in the workshop is to organize and run overseas residential, collaborative R&D challenges (Figure 7). This approach is inspired by ‘hackathon’ events – design sprints for computer programmers to deliver a specific product, often functioning software or hardware, by the end of the event. Following the hackathon example, these collaborative R&D challenges will *deliver a specific research or technology result by a specified deadline*. The deliverable result of each event must be specific, well-defined and sufficiently ambitious to motivate participation by talented scientists and engineers. Deliverable results could include validation of an unproven scientific theory, developing a new experimental or computational method, or conceiving and demonstrating a technology to achieve a specific function. The timeframe will be specified for each event and will be short enough to be challenging, and not to exceed 6 months.

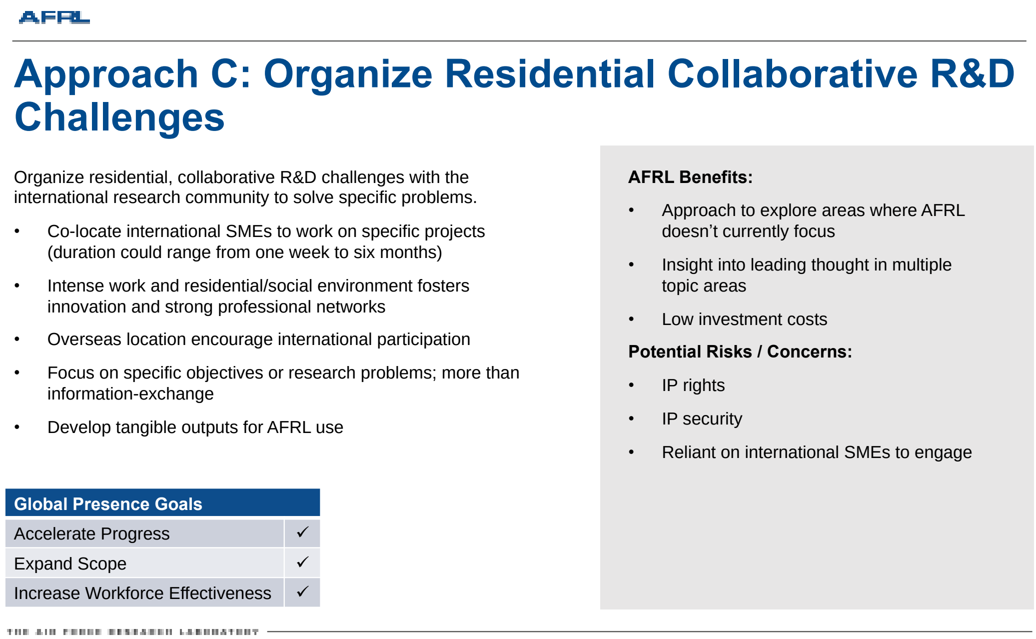

Figure 7. Approach C Characteristics of organizing residential R&D collaboration challenges.

Collaboration is an essential feature of these events. Participants form into collaborative teams to overcome scientific or technological gaps by tackling initial stages of theory and research, or by conceiving and exploring innovative new technical concepts to accomplish an AF-relevant task. The ability to work together with respected peers within a particular discipline or across disciplines is a strong motivator for talented scientists and technologists. To strengthen opportunities for intense collaboration, these are residential events. This follows the successful model of the 1956 Dartmouth Summer Research Project on Artificial Intelligence [7]. This event included a total of 20 participants, and over roughly 8 weeks they built the intellectual foundation for the field of artificial intelligence (AI). This workshop is largely considered to be the start of that field. The Kavli Institute for Theoretical Physics (KITP) is another exemplar. Located at the University of California, Santa Barbara, it sponsors multi-month programs with up to100 participants in residence and working together daily. The daily sharing of work and social events within a diverse group of talented individuals promotes innovative solutions, provides cultural immersion, and helps form long-term professional networks. These events would be held at overseas locations to better access international innovation and talent.

The presence of a challenge is another essential feature of these events. Talented individuals are drawn to solve difficult, meaningful challenges to develop mastery of their technical skills and to achieve a sense of purpose [8]. The challenge can be represented by the difficulty of the objective, the significance of the outcome, or the limited timeframe. The challenge can also come by competing with other collaborative teams, so that these events can be a single team collaborating toward a specific goal or multiple collaborative teams that compete with each other. The Defense Advanced Research Projects Agency (DARPA) was an early adopter of multiple team, collaborative challenges. The DARPA Grand Challenges in 2004 and 2005 developed and demonstrated autonomous robotic ground vehicles for hazardous military operations [9]. DARPA has subsequently used competitions between collaborative teams for other challenges on topics that include cybersecurity, social networking and micro-unmanned air vehicles (UAVs). NASA has also used technology competitions to develop robotic systems for mining the surface of the moon [10].

AFRL is arguably one of the first government agencies to use competition between multiple collaborative teams as an effective approach to develop new technologies. AFRL initiated the University Nanosat Program as a satellite design and fabrication competition in 1999 [11]. The University Nanosat Program supports small satellite R&D, integration and flight testing while training the next generation of space professionals through a two-year competition between U.S. university teams. By 2011, roughly 4500 students and 27 universities had participated in the program, launching three satellites. The University Nanosat Program includes two AFRL Technology Directorates – the Space Vehicles Directorate (AFRL/RV) and the Air Force Office of Scientific Research (AFRL/AFOSR) – and is jointly administered with the American Institute of Aeronautics and Astronautics (AIAA) and the NASA Goddard Space Flight Center.

The collaborative R&D challenge approach proposed here has already demonstrated many benefits. When integrated into the broader technology strategy of an organization, well-designed challenges and prize competitions significantly expand the number of ideas developed by only paying for success. They reach more deeply into the innovative talent pool and explore multi-disciplinary and out-of-discipline approaches. This was best stated by Lt. Col. Scott Wadle, the U.S. Marine Corps liaison to the DARPA Grand Challenge [12], “That first competition created a community of innovators, engineers, students, programmers, off-road racers, backyard mechanics, inventors and dreamers who came together to make history by trying to solve a tough technical problem. The fresh thinking they brought was the spark that has triggered major advances in the development of autonomous robotic ground vehicle technology in the years since.” Finally, this approach significantly reduces risk by eliminating the need to predict at the proposal stage which team or approach is most likely to succeed. These benefits are embraced in the America COMPETES Reauthorization Act of 2010, which gives broad authorities for Government agencies to offer prizes. A summary of the 34 Government agency prize competitions conducted in FY 2014 under the this Act, as well as a number of challenges conducted under other authorities (including four from AFRL), is detailed in a report from the Office of Science and Technology Policy (OSTP) [13].

There are two concerns in implementing this approach. Since the residential R&D challenges will be conducted overseas and will draw on international talent, sensitive technologies cannot be included. Also, innovative talent is often motivated to solve grand challenges with major societal or economic impacts. Defense technologies in general and weapons technologies in particular may not inspire the same level of engagement from the international talent pool. As a result, those challenges within the AFRL portfolio that can inspire the most talented individuals to participate need to be carefully evaluated and identified.

5.2.4. Approach D: Strategically influence international S&T funding

The last approach considered is to strategically influence international S&T funding (Figure 8). Through AFOSR, AFRL provides small research grants or leverages existing overseas investments through the European, Asian and South American Offices of Aerospace Research and Development (EOARD, AOARD and SOARD, the so-called XOARDs). However, AFRL has no mechanisms or strategies to proactively influence the direction of international investments. Several concepts were identified in the divergent thinking session of Task 3 to strategically influence overseas S&T funding. One concept is for XOARD staff to actively seek opportunities to influence AF-relevant R&D investments by offering to jointly fund the research with overseas funding agencies. A related Task 3 concept is to establish an AFRL Venture Capital fund to co-invest in overseas R&D that may produce AF-relevant technologies. Both approaches can influence decisions at overseas funding agencies by reducing their risk and funding level. These approaches also give AFRL a stake in the developed technology. A third approach is to negotiate the assignment of AFRL technical staff within overseas funding agencies. Funding agencies such as the National Science Foundation (NSF) and DARPA commonly hire program officers from universities, industry or other Government agencies. This may not commonly be done with overseas staff but may be investigated as a possible approach.

5.3. Suggested improvements to existing overseas programs and processes

In addition to the four approaches developed at the workshop, six improvements to existing programs and processes were suggested to enhance overseas collaboration (Figure 9). The first concept is embodied in Approach B discussed above. The second suggestion – finding ways to hire foreign talent to work with AFRL researchers at domestic facilities – already has support beyond the Task 3 workshop. The AF Science and Technology Strategy [3] specifically mentions expanding our engagement with both national and global talent using ideas and approaches from service pilot programs such as the U.S. Army Research Laboratory (ARL) Open Campus. By exploring innovative approaches to address security concerns, ARL is opening areas of its Adelphi Laboratory Center to host visiting scientists and engineers, including foreign nationals [14]. As a further opportunity to explore, ESEP researchers come to the U.S. with security clearances already processed through their respective Government agencies.

6. TASK 4: COMPARE EXPERIENCES WITH PROPOSED OBJECTIVES AND APPROACHES

6.1. Approach

Insights from the interviews of Task 2 were compared against the AFRL objectives for establishing a physical presence within overseas laboratories in Task 1, and against the approaches developed in the Task 3 workshop. The results of these comparisons are given below.

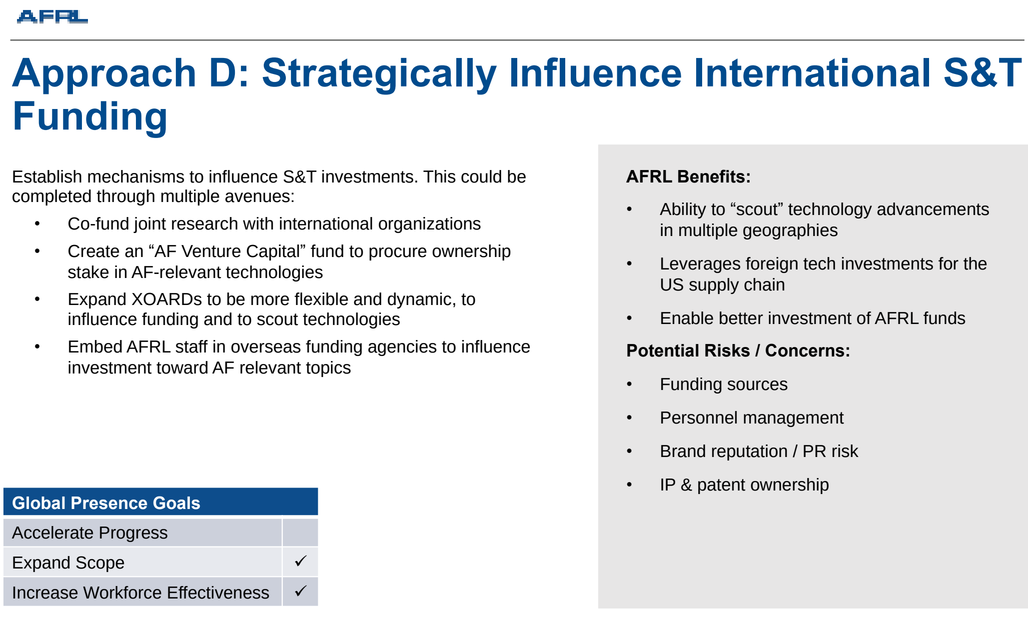

Figure 8. Approach D Characteristics of strategically influencing international S&T funding.

AFRL

Suggested Improvements to Existing Overseas Programs and Processes

1. **Expand scope of existing programs (WOW, ESEP, VSP, SBIR/STTR, and other similar programs)**
   Reduce limitations (especially duration) and more broadly define program parameters to better utilize these programs
2. **Expand use of international program agreements**
   Reduce organizational constraints to working side-by-side with foreign nationals (especially for ESEP S&Es working within AFRL); coordinate timing of application and funding process; standardize processes; and provide access for foreign researchers to work with AFRL researchers (either on base or at local universities)
3. **Enhance adjunct status and thesis committee**
   Encourage adjunct positions and thesis committee participation (including with international universities)
4. **Virtual Collaboration with International Partners**
   Provide tools/access to more easily collaborate with international researchers, academics, and partners
5. **Incentivize TD support of international workforce development opportunities**
   As appropriate, standardize policies across division and branches to encourage international collaboration opportunities
6. **Reduce barriers to participate in and travel to international conferences**
   Increase cross-TD awareness regarding availability of and regulations guiding participation in international conferences

THE AIR FORCE RESEARCH LABORATORY

Figure 9. Suggested improvements to existing overseas programs and processes.

6.2. Results

6.2.1. Comparison of interview results with objectives from Task 1

The primary reason for establishing overseas laboratories is *access to talent* – all of the interviews provided a strong and unanimous consensus on this finding. *Leveraging overseas funding* was another main objective. One major defense contractor and both universities interviewed said that they use their overseas research facilities to obtain regional or Government grants for R&D and for expanding facility infrastructure in the foreign country. Seven of nine organizations leverage overseas investments less directly, by opening laboratories near universities that are strongly supported by overseas grants and then accessing talent that is trained at these facilities. *Lower cost talent* was mentioned as an objective in a smaller number of interviews. The first two of these goals from the interviews (access to talent, leveraging funding) align directly with the findings in Task 1 of this study – that access to talent and leveraging overseas R&D investments can achieve the higher AFRL objectives of accelerating and expanding the scope of AF-relevant technologies. The higher motivations driving U.S. industries and universities to search for overseas talent and funding are: improved product performance and affordability; forming new partnerships; complementing domestic technical competencies; and building a stronger overseas market presence or brand recognition. The first two purposes align with broad AF objectives. Improving product performance and affordability is specifically mentioned in the 2018 National Defense Strategy, and forming new international partnerships is called for in both the 2018 National Defense Strategy and the AF Science and Technology Strategy and is the specific the motivation for this study.

There are differences between findings in the interviews and the results of Task 1. Lower cost talent and access to overseas markets are fundamental to the need to generate revenue and produce a profit in industry but are not motivations for the Air Force. Comments during the interviews made it clear that industry and universities use overseas talent to *complement and add to their domestic talent pool*, but they do not use the overseas laboratories to *develop their domestic workforce*. Eight of nine organizations said it is important to have a small U.S. employee presence at the overseas facilities, but to instill and reinforce performance expectations and core values in the foreign workforce rather than to develop the domestic workforce. Only two organizations said it is important to embed U.S. personnel in the overseas facilities to improve organizational competency or workforce effectiveness of the U.S. employees. Supporting this approach for U.S. businesses and universities, legal protections are adequate to safeguard proprietary information and intellectual property produced by foreign talent. Within the DoD, subject matter experts contribute to the mission by applying scientific and technological knowledge to develop warfighter systems. Considerations of national security therefore require that the most talented subject matter experts within the AF reside within the national talent pool. Developing the international awareness and effectiveness of the most capable AFRL scientific and technical talent is thus a major objective for the AF, and this is strongly supported by both the 2018 National Defense Strategy and the AF Science and Technology Strategy.

As another difference between interview results and Task 1 goals, accelerating the pace of technology development was not an important motivation for industries or universities. Surprisingly, only one of nine organizations interviewed said that accelerating technology was an important factor. Over two-thirds of the respondents said that speed can be increased more easily in the U.S. since it eliminates barriers due to international laws and cultural challenges. The respondents were equally adamant that establishing overseas laboratories to build a 24/7 workflow provides no net benefit and is not a motivation. As a quote from a leading IT company, "We and others have tried 24/7 with software development. It doesn't work well. It requires integrated teams who are working on the same workstreams and that is hard to pull off." Major defense contractors ("…it's not about 'follow-the-sun' production, that doesn't work…") and large, global technology companies ("…there's no net benefit for 24/7 development…") provided similar statements. Some companies were initially motivated to build overseas facilities to accelerate the pace of development, but years of experience didn't support their expectations.

The motivation for accelerating the pace of development within AFRL and the DoD is clearly described in the 2018 National Defense Strategy and the AF Science and Technology Strategy, strongly supporting this Task 1 objective. Since this objective has not been achieved after years of industry experience with overseas laboratories, AFRL must carefully evaluate its methods to reach this goal. An important observation from this study is that industries and universities develop technologies in overseas facilities in exactly the same way as is done in domestic facilities, and so AFRL may need to consider unique or different methods for conducting overseas R&D than is done domestically. The focused application of Approach C (Section 5.2.3) is one such method proposed in this study that may accelerate the rate of technology development.

Finally, expanding the scope of effort was identified as a major objective for AFRL in Task 1, but it was not important for any of the interview respondents. Nevertheless, this is a goal of strategic importance for AFRL and is emphasized in both the AF Science and Technology Strategy and the 2018 National Defense Strategy.

6.3. Comparison of interview results with approaches from Task 3

6.3.1. Approach A: Establish physical AFRL overseas facilities

All the organizations interviewed indicated AFRL should only consider establishing a physical overseas facility if there is a specific research need that requires expertise unavailable in the U.S. As a quote from a major university, “They (AFRL) should figure out what they want to do that they couldn’t do in the U.S. If there isn’t anything they couldn’t also do in the U.S., they’re much better off just doing it in domestically.” Creating an overseas facility to provide a 24/7 research capability should not be a determining factor, if this is needed it can be done more effectively within the U.S. Building an overseas brick-and-mortar facility is by far the most costly approach for accessing overseas talent, and it can take 3-5 years or longer to become productive.

6.3.2. Approach B: Embed AFRL technical staff in overseas organizations

As a broad consensus, respondents agreed that it is more efficient and cost effective to send researchers to existing international research facilities, rather than creating a new overseas laboratory. Five organizations recommended sending employees to universities or government host organizations to conduct research, and four interviewees specifically suggested that AFRL send researchers to overseas universities for graduate school to learn new technologies. It was further advised that AFRL create long-term relationships with those universities. According to a large, global technology company, “Having workers embedded in a country and company for an extended period allows them to deepen their understanding and expertise in a field or industry. In addition, they can develop meaningful relationships with counterparts to build trust.” This was supported by a major defense contractor, “You can look at the top global universities on a topic. For us, the top university is in the U.S. and the number 3 one is in [host country]. We invest in both institutions and we are looking at funding scholarships between the two universities to cross-pollinate students and ideas.” None of the institutions interviewed had experience embedding researchers in a foreign Government laboratory, but this option is already exercised by AFRL through the ESEP program (with limitations) and should be strongly considered.

6.3.3. Approach C: Organize residential, collaborative R&D challenges

The interviews were focused on establishing physical overseas laboratories, and so none of the respondents provided comments relating to organizing residential, collaborative R&D challenges.

6.3.4. Approach D: Strategically influence international S&T funding

A conclusion drawn from the interviews is that establishing an overseas presence may open opportunities to access new funding sources through coordination with the local government, businesses, and universities. According to one company, “One benefit of an overseas location is access to regional grants like EU and Asia government grants. These grants have clauses that the work needs to be done in that country. In our [host country] location, we had access to lots of grants we couldn’t get without that presence.” Five organizations indicated they worked with the host country’s government to identify research funding opportunities, and two organizations co-invested in research projects with the host country. Additionally, four organizations indicated the importance of coordinating with local businesses and universities to identify potential funding and cost-sharing opportunities. “We strategize around partnerships, like the Government research lab in [host country]; we co-invest in projects aligned with [our organization’s] and [host country’s] needs.”

7. TASK 5: EVALUATE FUNCTIONAL REQUIREMENTS

7.1. Approach

This task began by selecting those approaches that were most likely to achieve the objectives from Task 1 while minimizing cost and risk, and eliminating the other approaches from further consideration. The policies, processes and authorities needed to implement the selected approaches were evaluated in the remainder of this task. A functional team was assembled representing: personnel; cost and finance; contracting; legal; foreign disclosure; and information security (Appendix B). The team members were briefed on the objectives of the present study and on the approaches selected for further evaluation. This team was charged with describing the policies, authorities and processes in their respective functional domains needed to implement each of the selected approaches and to determine if any implementation barriers existed. The results are given below.

7.2. Results

7.2.1. Down-select decision

The four recommended approaches and six suggested improvements from Task 3 were briefed to the AFRL Commander and Executive Director on 29 October 2019. Consistent with the industry and university experiences in Task 2, the risk and cost for Approach A (Establish physical AFRL overseas facilities) were considered to be too high for the expected benefits. Approach D (Strategically influence international S&T funding) was considered difficult to implement with a low benefit. As a result, Approach B (Embed AFRL technical staff in overseas organizations) and Approach C (Organize residential, collaborative R&D challenges) were selected for evaluation by the functional teams in this task.

7.2.2. Approach B: Embed AFRL technical staff in overseas laboratories

As already discussed, AFRL currently places research staff in overseas laboratories through programs such as Windows on the World (WOW) and the Engineer and Scientist Exchange Program (ESEP). These programs provided a functional baseline of experience to address the processes for Approach B. A summary of the processes associated with placing an AFRL researcher in a foreign laboratory is given below for each of the functional domains considered.

7.2.2.1. Personnel

A simple temporary duty (TDY) is used to embed AFRL technical staff in foreign countries for assignments up to 179 days. A TDY employee works for the U.S. Government and is temporarily stationed away from their permanent job location. Rules and processes for TDYs are outlined in the Joint Travel Regulation (JTR). For assignments longer than 179 days, AFRL/DPMP establishes an Operating Location (OL) using the guidelines provided in AFI 38-101, “Manpower & Organization”. Each OL is aligned to the Technology Directorate owning the requirement. Several steps are required to process an OL, this process is almost completely within AFRL and the Air Force Materiel Command (AFMC). The total time needed to process an OL within AFRL and AFMC can range from 5-29 calendar days. There are two potentially long lead-time processes associated with this procedure. The AFRL sending organization develops a Memorandum of Agreement (MOA) with the host organization, which involves the

Department of State for overseas locations. The timeline for this process can vary widely depending on coordination requirements of the host nation. The second long lead-time event is that the servicing personnel organization submits a request to update the Defense Finance and Accounting Service (DFAS) and the Defense Civilian Personnel Data System (DCPDS) to include the new overseas position organizational address and pay table, this can typically take 30 calendar days. Once the OL is established, the employee can begin the process for a permanent change of station (PCS), which is outlined in the Joint Travel Regulation (JTR).

7.2.2.2. Cost estimating and analysis

Cost estimates for overseas assignments up to 179 days are straightforward and are based on the DoD per diem rates for the host country and city or location. Overseas assignments lasting more than 179 days involve a permanent change of station (PCS) and require a more detailed cost estimate. These estimates use historical costs from international exchange programs such as ESEP and WOW, as well as data available in the International Cooperative Administrative Support Services (ICASS) system. Through ICASS, the Department of State (DoS) publishes the costs needed to provide administrative support through its foreign diplomatic and consular posts to U.S. Government employees assigned overseas. In foreign countries with U.S. military bases, such as the U.K., Germany, Japan or South Korea, administrative support of the AFRL employee is provided by the nearest military base and no ICASS costs are incurred. Other major factors in the estimate are costs to move the employee and their household, additional salary costs associated with the host country, and an education allowance for children of the researcher. The moving expense is processed through SAF/IAPC and includes PCS funds and miscellaneous expenses such as temporary quarters and transportation allowance. Additional salary costs include the cost of living allowance and the living allowance in lieu of locality pay for the host country. The key factors in the cost to place an AFRL employee overseas are the host country selected, the length of stay, and the number and ages of children. In rough numbers, the cost to send an AFRL researcher to a foreign country for 12 months can range from $100K to $250K.

7.2.2.3. Contracting

Some type of formal relationship must be established between AFRL and a foreign laboratory in order to allow placement of an AFRL employee. Collaborative R&D with overseas Governments use instruments such as Memoranda of Understanding (MOUs) and Project Agreements (PAs), while a Cooperative Research and Development Agreement (CRADA) is used to partner with non-Federal parties. None of these instruments allow for the transfer of funding and are thus not considered acquisition instruments. As a result, CRADAs, MOUs and PAs are discussed in Section 7.2.6. (Legal).

Interactions with overseas universities typically use an assistance instrument such as a grant or a cooperative agreement. An assistance instrument is used when transferring a *thing of value* to a recipient to carry out a *public purpose* through *support or stimulation* authorized by a statute. A *thing of value* is typically money to conduct research. The requirement for a *public purpose* can be met in several ways. One example is the development of a commercial product that also satisfies a military requirement. Government projects that will contribute to the U.S. economy or have public health benefit also meet a public purpose. *Support or stimulation* means that the project needs Government assistance to fulfill its objective, this is primarily achieved by the funding to support the effort. Finally, the project must be authorized by statute. U.S. Code 10 USC 2358 covers the use of assistance instruments for R&D, and meets this requirement.

A cooperative agreement is typically the appropriate vehicle, since embedding an AFRL researcher in the overseas university is a primary goal. Unlike a grant, this instrument anticipates a much closer, interactive relationship between the parties. Cooperative agreements must be competed to the extent practicable, but with appropriate justification, this allows direct engagement with the university. Important considerations such as intellectual property and security can be included in the cooperative agreement negotiations. An alternative vehicle is Other Transactions, however, this requires a 50/50 cost share between the U.S. Government and the overseas organization, and it is limited to cases where a standard contract, grant, or cooperative agreement is not feasible or appropriate, significantly limiting its use.

7.2.2.4. Legal

R&D interactions with foreign entities are regulated through legal instruments such as Cooperative Research and Development Agreements (CRADAs), Memoranda of Understanding (MOUs) and Project Agreements (PAs). The AFRL can enter into CRADAs with industry and academia, while MOUs and PAs are used to form partnerships with foreign Governments. All of these instruments include activities involving basic research (budget activity, BA1) and advanced research (BA2).These instruments give protections for intellectual property (IP), data rights and controlled unclassified information (CUI), and address potential data breaches. These will be discussed further in Section 7.2.7. (Foreign Disclosure). AFRL has significant experience in establishing each of these legal instruments for current collaborative overseas activities and international exchange programs. The primary issue with these instruments is that it can take up to one year to execute an international CRADA or a PA, and it can take up to 3 years to approve an MOU required to support a PA. These timeframes can degrade the ability to establish a timely and effective international R&D partnership since rapid progress on the motivating science and technology can render the initial document significantly outdated by the time it’s signed and executed.

7.2.2.5. Foreign disclosure

Foreign disclosure is concerned with protecting U.S. Air Force classified and controlled unclassified information (CUI). A foundational element of U.S. Air Force disclosure policy is the requirement that the recipient agrees not to transfer the information to another nation without first requesting permission from the U.S. Air Force; that they will only use it for military purposes; and that they will protect it to the same degree as we do. These are generally referred to as non-transfer; use; and protection requirements, and they are included in the legal instruments used by AFRL to establish foreign partnerships. Foreign disclosure requirements for a particular agreement start by defining the AFRL technology objectives through a summary statement of intent (SSOI), identifying the benefit to the U.S. through a quid pro quo document (QPQ), and then identifying the information that would need to be disclosed.

Many international collaborative R&D efforts occur fully within the field of basic science and sharing of information in the public domain. Such efforts do not require Foreign Disclosure Office (FDO) approval because information in the public domain is generally considered to be available to the global public, including our international collaborators. Classified and controlled unclassified information is subject to U.S. export control laws and regulations through the Department of State’s International Traffic in Arms Regulations (ITAR) and the Department of Commerce’s Export Administration Regulations (EAR); therefore, its disclosure to foreign persons must be consistent with these policies. In the U.S. Air Force, requests for classified and controlled unclassified information disclosure to foreign nationals is approved by FDOs consistent with delegation of disclosure authority letters (DDLs) issued by SAF/IAPD. A DDL is included in the legal documentation supporting an international agreement such as an MOU or a PA that may authorize us to share controlled information with foreign governments and (potentially) their contractors and universities. To comply with the ITAR and EAR, AF organizations must ensure that exports (including information) are covered by a signed international agreement as described in AFI 16-201. Requests by AFRL to share information through an existing international agreement are sent to the servicing FDO and can be approved within 10 working days. If an international agreement is not in place, the servicing FDO coordinates the request with the MAJCOM FDO and potentially SAF/IAPD. A request that requires a new PA under an existing MOU can add up to 1 year for approval, a request that requires a new MOU can add up to 3 years for approval.

7.2.2.6. Information security

Controls for protecting classified information are covered by DODI 5200.01, Volume 3 and the policies for protecting controlled unclassified information (CUI) are contained in DODI 5200.48. There are currently no DoD instructions for protecting information associated with basic research (budget activity, BA1); this is currently being addressed. DoD guidance for protecting export-controlled information defers to the Departments of State and Commerce through the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). Requirements and controls to provide information security are specified in agreements and arrangements such as MOUs and PAs, these include the non-transfer, use and protection clauses described in Section 7.2.7. Scientists and engineers traveling to a foreign country receive anti-terrorism training and a country threat briefing from the Air Force Office of Special Investigations (AFOSI) to ensure information security. Additional counter-measures depend on the threat posed by the country involved – countries with a medium or high risk are generally avoided. An AFRL S&E embedded in a foreign laboratory represents a higher risk for information security due to lack of control of the physical information technology system, easier access by foreign nationals, and less scrutiny of foreign nationals in the workplace, especially at universities. In addition to the typical protections used in existing international exchange programs, additional suggestions are given in Recommendations at the end of this report.

7.2.3. Approach C: Organize residential, collaborative R&D challenges

The U.S. Air Force seems to have no previous experience in using residential, collaborative R&D challenges in the international arena, and so innovative functional approaches and processes may be required. Other Government agencies have begun to explore similar programs, and so AFRL can learn from these, which include the Global Innovation Through Science and Technology (GIST) network run by the Department of State [15], the U.K. Defence and Security Accelerator (DASA) [16], and the Global-X Agile Innovative Research Challenge run by the Office of Naval Research Global [17].

7.2.3.1. Personnel

This approach requires a simple Temporary Duty (TDY) assignment for up to 179 days. Rules and processes for TDYs are outlined in the Joint Travel Regulation (JTR).

7.2.3.2. Cost estimating and analysis

Processes do not currently exist to conduct a realistic cost estimate for a collaborative, residential research challenge. As a starting point, cost analyses will be conducted on comparable domestic events run by other organizations. Data from residential events run by organizations such as the Kavli Institute for Theoretical Physics will be considered, as well as non-residential challenge events such as those described in [13]. International programs such as the Global Innovation Through Science and Technology (GIST) network run by the Department of State [15] may also provide useful costing data and experience. Key data will include costs associated with the host country, specific venue, delivery method, scale and duration of the event.

7.2.3.3. Contracting

Under the terms of 10 USC 2374a, the DoD may award prizes to recognize outstanding achievements in basic, advanced, and applied research, technology development, and prototype development that have the potential for application to the performance of the military missions of the DoD. Three distinct contracting approaches are considered for residential, collaborative R&D challenges. In the first, AFRL takes full responsibility to organize and execute the event. The Federal Acquisition Regulation (FAR) Part 25, as supplemented, covers acquisition of foreign supplies and services and also covers contracts performed outside the U.S. – both apply in this case. There are a variety of statutory and policy requirements which may or may not apply depending on the supplies and services being acquired, the actual foreign country involved, and the value of the proposed procurement. Once these details are decided, a contracting strategy would need to be developed in order to accurately predict the implications. The second approach is to hire a domestic service contractor to organize and execute the event. With this approach, AFRL could use standard acquisition procedures to hire a service company to help define the nature of the competition, promote the event, and address local logistical issues. The company would be responsible for ensuring compliance with all local laws and procedures. The third option is for AFRL to partner with a foreign organization for the event. The foreign organization would be responsible for the actual logistical support for the event and the awarding of contracts and/or prizes to the winners. AFRL involvement would be limited to inputs on topic areas, evaluations, and funding of awards. For example, if the UK is identified as the location for the proposed event; AFRL could work with the U.K. Defence and Security Accelerator (DASA) [16] to conduct the event as a task under the existing Combating Terrorism Research & Development MOU between the U.S. and the U.K. This approach has the advantage of allowing the partnering country with the most knowledge of applicable laws and procedures to take the lead while still providing AFRL insight and access to the technology.

7.2.3.4. Legal

No additional legal barriers to running an international, collaborative, residential R&D challenge were identified beyond those discussed in Section 7.2.2.4 for Approach B (Embed AFRL technical staff in overseas laboratories). Guidance on legal policies and processes associated with such events may be available by studying the related programs run by the DoD and the DoS in the U.S. and from the DASA program in the U.K.

7.2.3.5. Foreign disclosure

The main information disclosure anticipated for a collaborative, residential, international R&D challenge is in advertising the technical objectives and the criteria for success. If any such information is export-controlled, controlled unclassified information (CUI) or classified information, a legally binding mechanism to ensure non-transfer, use, and protection requirements would be required. As previously stated, such disclosure would only be approved if it could be authorized for disclosure to the parent Government of each of the proposed participants. This could provide a major barrier, and so challenge problems will likely be limited to those requiring disclosure of uncontrolled information only. Data generated by domestic U.S. participants would also need to remain in the uncontrolled domain.

7.2.3.6. Information security

No additional information security barriers to running a collaborative, international, residential R&D challenge were identified beyond those discussed in Section 7.2.2.6 for Approach B (Embed AFRL technical staff in overseas laboratories).

7.2.3.7. Summary

The policies, processes and authorities needed to support the two approaches for international engagement recommended here (Approach B: Embed AFRL technical staff in overseas organizations and Approach C: Organize residential, collaborative R&D challenges) are not fundamentally different from those for existing international exchange programs. The processes, policies and authorities are in place and are generally well-practiced within AFRL. As a result, this Task did not identify any new barriers to hinder implementation of these two approaches.

8. TASK 6: RECOMMENDATIONS

Four approaches for deepening AFRL access to overseas S&T talent, facilities and funding were developed to accelerate creation and development of AF-relevant technologies, expand scope and quality of AF-relevant technologies, and increase AFRL workforce competency and effectiveness. These objectives and approaches were compared against extensive knowledge and experience in establishing overseas laboratories that was obtained through telephone interviews with multi-national companies and major universities. As a result of these efforts, this study makes the following recommendations:

1. Do not build or lease physical overseas laboratory facilities

The effort, cost and risk for establishing an AFRL-specific overseas physical laboratory are by far the highest of the options considered here. The time needed to begin showing a return on investment is typically three to five years, requiring a constancy of purpose that may be difficult to maintain through DoD budget and administration changes. This approach is inflexible – the laboratory facility is tethered to a specific country, and it is usually tailored to a particular subset of science and technology that is difficult to adapt with changing requirements and technology opportunities (similar to domestic laboratory facilities). While this represents the most effective approach for accessing overseas talent, other approaches developed in this study provide only slightly reduced benefits with improved flexibility and dramatically reduced cost, time and risk. This recommendation is supported by comments from industry experts, who strongly advised that AFRL should only consider building an overseas laboratory to do research that can't be done in the U.S. Finally, this recommendation is consistent with the decision made by the AFRL Commander and Executive Director on 29 October 2019.

2. Expand, simplify and fully utilize approaches to embed AFRL technical staff in overseas laboratories

The effectiveness of programs to embed AFRL scientists and engineers in overseas laboratories is characterized by five main features:

- **Type of host laboratory:** Government, University, Industry
- **Participant experience level:** DR-02, DR-03, DR-04+
- **Duration:** ≤ 6 mo, 12 mo, 18 mo, ≥ 24 mo
- **Information level:** Public release (including basic science), controlled unclassified information (CUI), classified
- **Approval timeline:** ≤ 3 months, 3-12 months, >12 months

Considering just the first three characteristics, programs currently available to AFRL cover only 27% of the possible assignments (Figure 10). *AFRL cannot presently assign researchers of any experience level to universities or industry labs for more than 179 days, and S&Es with expertise beyond the DR-02 level cannot be embedded in overseas Government laboratories for less than 2 years. These are serious gaps.* Enhancements included in Approach B: Embed AFRL technical staff in overseas laboratories, overcome most of these limitations. This recommendation envisions a single program (or a small suite of related programs) for overseas assignments covering the full spectrum of laboratory types, experience levels and durations, simplifying the present patch-work of limited-scope programs. *Additional enhancements in this recommended approach include:*

- AFRL funding of research conducted by the technical staff at the overseas laboratory to deepen interactions with the embedded AFRL technical staff

- an ability to assign either individual researchers or small teams
- the ability for AFRL to assign work duties to the embedded AFRL technical staff
- a strategic evaluation to identify partner laboratories and technical topics

To implement this approach, it is recommended that AFRL establish an innovative cross-functional team to develop and establish an inclusive, streamlined approach to international exchange programs and assignments. An objective of this team would be to minimize the number of programs needed to allow full flexibility for assignment duration, experience level of the candidate, type of host institute (Government, university, industry), level of technologies addressed and level of information shared. It is also recommended that this team develop a simplified and accelerated approval process with maximum use of local approval authorities. This may include revision of long lead-time approvals such as for international Cooperative Research and Development Agreements (CRADAs). Opportunities may exist to work with SAF/IA to speed this approval process by delegating authorities to AFRL.

It is also recommended that AFRL undertake an effort to identify countries that are investing heavily in research, talent and infrastructure on topics of strategic AFRL interest. Two examples mentioned earlier in this report are [dstl] at Porton Down in the U.K. and the Korean Institute of Basic Science. There are certainly other opportunities. It is further suggested that AFRL establish criteria for prioritizing these opportunities by considering factors that include specific benefits, method of engagement, expected outcomes and exit criteria.

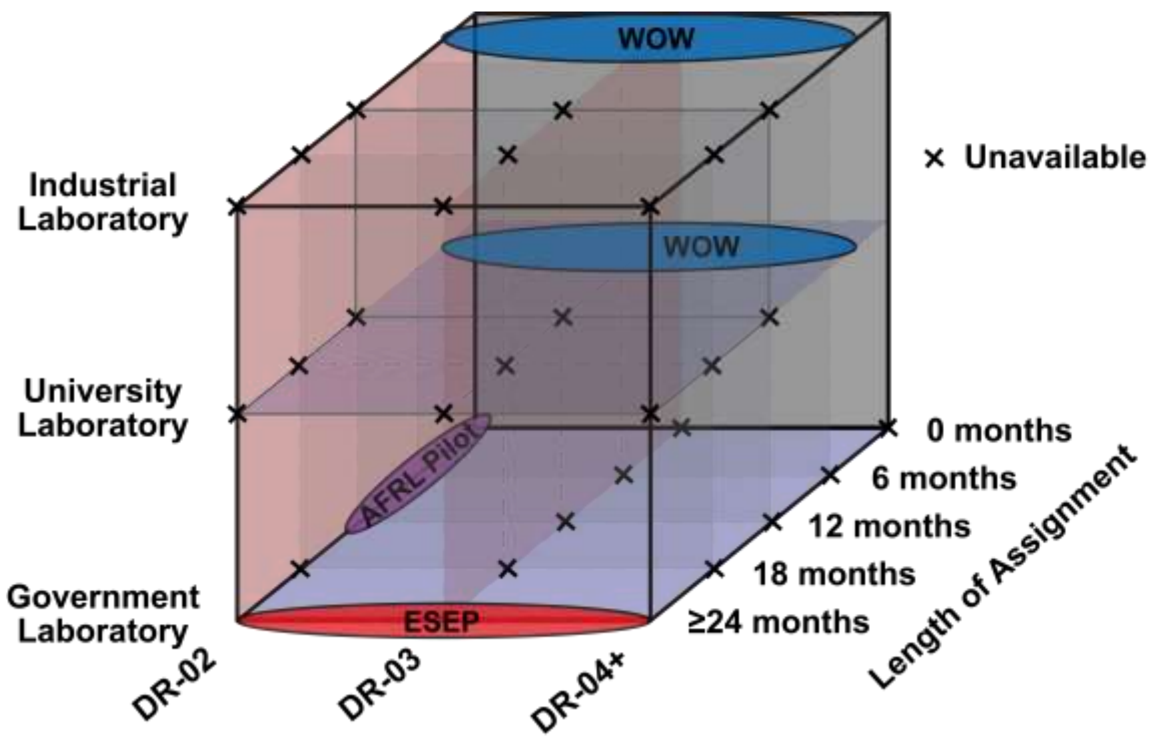

Figure 10. Selected characteristics of programs available for embedding AFRL technical staff in overseas laboratories. Most of the opportunity space for working in overseas laboratories is unavailable with current programs.

3. Conduct international, collaborative, residential R&D challenges

AFRL has successfully used domestic, collaborative R&D challenges to accelerate technology development and to tap into new talent and innovation. This study recommends extending this method to the international domain. This further suggests using residential events to maximize deep collaboration amongst participants and to establish enduring, international professional networks. The anticipated costs and risks of this approach are low, and experience within the Department of Defense (DoD) has shown dramatic improvements in innovation and return on investment (ROI) using this method.

To implement this approach, it is recommended to form a team consisting of innovative functional and technical experts to define the guidelines, organizational structure and processes needed to engage in such efforts. This team will gather information from similar events and activities, including events run domestically by U.S. agencies and events organized by foreign Governments such as the U.K. Defence and Security Accelerator (DASA). This team will establish approaches to select and prioritize challenge opportunities. It will also establish the most appropriate method to organize, advertise and run events – AFRL may accept responsibility for these activities or may seek a contractor to perform these functions. Other parameters associated with these events will be considered and defined, including: the collaborative format (single collaborative team or multiple collaborative teams that compete); the nature of the award (contract, prize, other); and the legal agreements required to secure intellectual property and information disclosure.

4. Do not pursue methods to influence international S&T funding

Opportunities may exist to influence the direction of international funding toward topics of interest to the U.S. Air Force. However, while the risk is assessed to be low, the payoff is also small. The approaches to implement this concept may be awkward to implement.

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APPENDIX A: CHARTER

A copy of the charter is provided below. The specific tasks performed and the order in which the tasks were actually conducted and presented in this report are slightly different from the charter. A detailed analysis of the cost, risk and benefit for the approaches identified in this study was initially planned (Task 5 in the charter). However, each of the two approaches selected for further evaluation offer a wide range of parameters that have direct impact on the cost analysis (see the two lists in Section 6.2). While this offers important flexibility and tailorability for each approach, it makes it difficult to perform a meaningful cost/benefit analysis without specifying the particular details of each assignment. These analyses were thus not done as part of this study, but will be required for specific engagements motivated by this study.

AFRL Global Presence Study

Purpose/ Problem Statement

DoD and USAF senior leaders have stressed the importance of increased collaboration and partnering to accelerate technology development through strategic synergy. In order to achieve these goals, AFRL must have continuous access to world-class scientific talent and facilities. As a result, AFRL senior leaders have asked, "Does it make sense for AFRL to have an overseas laboratory presence?"

Approach

The AFRL Executive Director has chartered a multi-functional team to conduct a 12 month study that will identify options for establishing an overseas laboratory presence and will compare expected benefits against risks and cost. Six tasks will be conducted. The first Task will collect data from organizations that have already established overseas laboratories and from previous studies with similar objectives. Task 2 is a workshop to clearly define the goals and expected benefits of an overseas laboratory presence and to recommend metrics for success, and Task 3 is a workshop to brainstorm the many ways to establish an overseas laboratory presence and to recommend approaches that are most likely to achieve the goals. The fourth Task will evaluate in detail the functional requirements, risks and costs for each of the preferred options. Task 5 will compare the benefits with the costs and risks and will identify options with the best return on investment. The last Task will compile the findings and recommendations into a final report. These Tasks are described in more detail below.

Task 1 – Collect existing data

US aerospace industries have already established an overseas laboratory presence. Interviews will be held with selected companies to determine their motivations and to learn from their experiences. This Task will also determine if US universities have an overseas laboratory presence and will collect relevant information from existing models. A search will be conducted for studies that may have already been done elsewhere within the DoD or other US Government Agencies with similar objectives. Relevant information and insights from Government agencies such as NSF and NATO will also be sought. The output of this Task will document the knowledge and experience associated with establishing a laboratory presence in overseas locations from these different sources.

Task 2 – Establish the goals

A 1 day workshop will be held to discuss the goals for establishing overseas laboratories. Discussion will consider access to and leverage of foreign talent and resources; improved innovation; and improved technology transition to foreign markets. The meeting will have a relatively small number of senior individuals with broad experience in different models for conducting science and technology in both domestic and international domains. The outcome from this workshop will include a clear statement of the intended goals, the expected benefits, and suggested metrics for success.

Task 3 –Explore and define options

There are many ways to establish an overseas laboratory presence. A workshop will be held to brainstorm the many ways that this might be done, discussing each of the aspects in the list below. To better focus the remaining Tasks, this workshop will also identify those approaches that are most likely to achieve the goals established in Task 2. The outcomes from this workshop will be a comprehensive list of the many ways to establish an overseas laboratory presence and a shorter list of the approaches most likely to achieve the goals with the anticipated benefits for each.

Business models: Does the overseas laboratory need to be operated by the AF or can it be contracted through a company or university? Can we work through one of the AFRL institutes such as WBI, Doolittle Institute or the Griffiss Institute?

Partner nations: Which partner nations have expertise and investments in technology areas of interest and offer the greatest leverage? Should we choose one or several partner nations?

Location and facilities: Is a physical or a virtual presence most desirable? What are the benefits, barriers, limitations and risks associated with locating 'behind the fence' at an overseas Government research site, co-locating within a university setting, or leasing a stand-alone facility? Do overseas 'research parks' offer benefits?

Staff: Should the overseas laboratories hire US-only staff, foreign staff only, or a mixed staff? Should US staff be AF only, DOD only, or cross-Agency? Can the US staff include non-Government (contractor) employees?

Technology areas: What technology areas offer the greatest payoff for international collaboration? Are strategic (hypersonic, AI…) or foundational (materials…) technologies most advantageous? Should efforts be restricted to basic research or can more applied work be included? Will the work be computational, experimental, or a blend of these? To what extent should innovation be a focus?

Task 4 – Document functional requirements

In this Task, the functional requirements will be evaluated for the models that are most likely to achieve the goals. The functional requirements will include contracting, budget and finance, security, data rights and data management, legal authorities, and personnel. International policy will also be considered. The final output from this Task will be description of the barriers to entry, the limitations, and the risks associated with the most promising models.

Task 5 – Perform cost vs benefit analysis

This task will compare the expected benefits against the entry barriers, risks and cost of conducting an overseas laboratory activity. Options with the best return on investment will be identified and final recommendations will be specified.

Task 6 – Prepare final report

The last Task will prepare a report summarizing the goals and benefits (Tasks 1, 2); the approaches considered as well as the models most likely to achieve the goals (Tasks 1, 3); the barriers, risks and cost (Task 3, 4); and a cost/ benefit analysis supporting final recommendations (Task 5) for establishing an overseas presence.

Team

The primary team members are listed below. Additional team members may be identified during the course of the study.

Lead: Dan Miracle

AFRL/CA: Jessica Salyers (cc: Jack Blackhurst, Tim Sakulich)

Contracting (AFRL/PK): Lisette LeDuke, Steve Ewers

Finance (AFRL/FM): Emily Duke, Angie Trego (cc: Jennifer Morgan)

International Office (AFRL/XPP): David Dahl, David Blair (cc: Ted Gallagher)

Legal (AFRL/JA): Paul Van Maldeghem

Personnel (AFRL/DP): Magdaline (Molly) Alfaro

Security (AFRL/DSI): Merle Cox, Paul Pedroso (cc: Rhonda Parker)

Schedule

Task 1 will begin immediately and will conclude by the end of October 2019. Participants for Tasks 2,3 will be identified immediately and the workshops will be scheduled for Sep 2019. Task 4 will begin with the conclusion of Tasks 2, 3 and will conclude by the end of Feb 2020. The cost/benefit analysis and recommendations (Task 5) will be completed by the end of Mar 2020. The final report will be delivered to the AFRL Executive Director by 31 May 2020.

JACK L. BLACKHURST, SES
Executive Director
Air Force Research Laboratory

APPENDIX B: AFRL GLOBAL PRESENCE STUDY CONTRIBUTORS

Task 1. Identify Objectives Workshop Participants

The following individuals participated in the workshop on 12 September 2019 to identify the objectives for establishing a physical presence within overseas laboratories:

Dr. Bill Borger	Propulsion Directorate (AFRL/RZ)	Past Director
Mr. Ted Gallagher	Plans and Programs, International Office (AFRL/XPP)	Chief
Dr. Dan Miracle	Materials and Manufacturing Directorate (AFRL/RX)	Senior Scientist
Dr. Rajesh Naik	711th Human Performance Wing (711 HPW/CS)	Chief Scientist
Dr. David Stargel	711th Human Performance Wing (711 HPW/CL)	Deputy Chief Scientist
Dr. Chuck Ward	Materials and Manufacturing Directorate, Manufacturing Technology Division (AFRL/RXM)	Chief

Col. Tim Lawrence (Information Directorate (AFRL/RI), Director, and formerly Air Force Office of Scientific Research International Office (AFOSR/IO), Director) was not present at the workshop but contributed to the final product.

Task 2. Document Industry/University Experiences, Organizations Interviewed

The internet search was performed by Mr. Aaron Schulman (Toffler Associates, Past Director) and the telephone interviews were conducted by Ms. Amanda Ku (Toffler Associates, Associate), Mr. Aaron Schulman and Ms. Denise Sughrue (Toffler Associates, Director). All three individuals contributed to analyzing and reporting the results of the interviews. The companies and universities that participated in the interviews were:

Boeing Global Research and Technology

General Electric Global Research

Georgia Tech, Panama Logistics Innovation & Research Center

Google, Inc.

IBM Research

Lockheed-Martin Corporation

Oracle Labs

Raytheon Technologies Research Center (formerly United Technologies Research Center)

Texas A&M Soltis Research Center

Task 3. Identify Approaches, Workshop Participants

The following individuals participated in the workshop on 16, 17 October 2019 to generate and develop ideas for establishing a physical presence within overseas laboratories:

Dr. Monica Allen	Munitions Directorate (AFRL/RWMFT)	Senior Electronics Engineer
Dr. Jeff Baur	Materials and Manufacturing Directorate (AFRL/RXCCM)	Research Team Leader
Dr. Mitch Bogle	Munitions Directorate (AFRL/RWME)	Research Scientist
Mr. David Dahl	Plans and Programs, International Office (AFRL/XPPI)	Liaison Officer
Dr. Paul Fleitz	Aerospace Vehicles Directorate (AFRL/RQQC)	Research Scientist
Dr. Kevin Gluck	711th Human Performance Wing (711 HPW/RHAC)	Principal Cognitive Scientist
Dr. Saber Hussain	711th Human Performance Wing (711 HPW/RHBB)	Principal Scientist
Dr. Misoon Mah	Air Force Office of Scientific Research, International Office (AFOSR/ION)	International Program Officer
Dr. Dan Miracle	Materials and Manufacturing Directorate (AFRL/RX)	Senior Scientist
Dr. David Stargel	711th Human Performance Wing (711 HPW/CL)	Deputy Chief Scientist
Dr. Augustine Urbas	Materials and Manufacturing Directorate (AFRL/RXAN)	Research Physicist

The workshop was facilitated by Ms. Amanda Ku (Toffler Associates, Associate) and Ms. Denise Sughrue (Toffler Associates, Director), who also participated in analyzing and refining the concepts and in reporting the results.

Task 5. Evaluate Functional Requirements, Participants

The following individuals performed the functional evaluations for this study:

Personnel (AFRL/DP)	Magdaline (Molly) Alfaro	Personnel Director
Finance (AFRL/FM)	Capt. Matt Markman	Finance Analyst
	Ms. Angie Trego	Division Chief
	Ms. Emily Duke	Deputy, Financial Management
	Ms. Jennifer Morgan	Deputy, Program Executive Officer
Contracting (AFRL/PK)	Mr. Steve Ewers	Procurement Analyst
Legal (AFRL/JA)	Ms. Sabra Tomb	Attorney-Advisor
	Mr. Paul Van Maldeghem	Chief Counsel
Foreign Disclosure (AFRL/XPPI)	Mr. David Blair	Foreign Disclosure Officer
	Mr. David Dahl	Liaison Officer
Information Security (AFRL/DSI)	Mr. Terry Allphin	Security Specialist
	Ms. Rhonda Parker	Information Protection Senior Functional

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

711 HPW	711th Human Performance Wing
AFB	Air Force Base
AFOSR	Air Force Office of Scientific Research
AFOSR/IO	Air Force Office of Scientific Research, International Office
AFRL	Air Force Research Laboratory
AFRL/DP	Air Force Research Laboratory, Personal Division
AFRL/DS	Air Force Research Laboratory, Information Security
AFRL/FM	Air Force Research Laboratory, Financial Management
AFRL/JA	Air Force Research Laboratory, Judge Advocate
AFRL/PK	Air Force Research Laboratory, Contracting Division
AFRL/RI	Air Force Research Laboratory, Information Directorate
AFRL/RQ	Air Force Research Laboratory, Aerospace Vehicles Directorate
AFRL/RX	Air Force Research Laboratory, Materials and Manufacturing Directorate
AFRL/XPPI	Air Force Research Laboratory, Foreign Disclosure Office
AIAA	American Institute of Aeronautics and Astronautics
CERN	European Organization for Nuclear Research
DARPA	Defense Advanced Research Projects Agency
DASA	Defence and Security Accelerator
DEA	Data Exchange Agreements
DFAS	Defense Finance and Accounting Service
DoD	Department of Defense
DoE	Department of Energy
DTIC	Defense Technical Information Center
EPSRC	Engineering and Physical Sciences Research Council
ESEP	Engineering and Scientist Exchange Program
GBRL	Global Basic Research Laboratory
HR	Human Resources
IP	Intellectual Property
ITAR	International Traffic in Arms Regulations
ITER	International Thermonuclear Experimental Reactor
ITEx	Innovative Teaming Exchange
MoD	Ministry of Defence
MOST	Ministry Of Science and Technology
MOU	Memoranda of Understanding
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
PA	Project Agreements
R&D	Research and Development
ROI	Return On Investment
S&E	Scientists and Engineers
S&T	Science and Technology
STEP	Short Term Exchange Program
TAA	Trade Agreement Acts
UK	United Kingdom