RESEARCH SUMMARY

Data-Enabled Approaches for Enhancing the Air Force Transformational Capability Pipeline

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ISSUE

- A key goal for the Transformational Capabilities Office (TCO) is to foster transformational capabilities across a range of initiatives.
- To propose, develop, and select which concepts to advance into the transformational capability pipeline, the TCO must extract information from data contained across many text sources that report capability gaps and technology programs, and combine it with human expertise and creativity.
- Machine learning (ML) and natural language processing (NLP) can be used to extract information from text sources on capability gaps and technology solutions.
- Subject matter expertise must also be captured and leveraged effectively to provide creative insight and make best use of the extracted information.

APPROACH

To understand how human-centered, data-enhanced (HCDE) decision processes can be used to determine which concepts to advance into the transformational capability pipeline, we used a multimethod qualitative approach that included a review of the relevant bodies of literature on development planning, along with interviews with senior leaders, technical experts, and subject matter experts from the Department of the Air Force (DAF) and the U.S. Department of Defense (DoD). The synthesis of our analysis revealed opportunities for the TCO to (1) use data science tools to extract information from vast databases of capability gaps, capability needs, and technology solutions; and (2) use a more diverse set of future-focused decision methods, called foresight methods, to leverage human expertise and creativity. We developed and implemented a proof-of-concept software tool, the Semantic Clustering Analysis and Thematic Exploration Tool, to extract information from free-text descriptions of capability gaps and technologies, and we combined the tool with foresight methods as part of an HCDE decisionmaking process. We demonstrate the data science tool and foresight methods in three case studies involving (1) highspeed vertical takeoff and landing, (2) Joint All-Domain Command and Control, and (3) human capital management.

continued

KEY FINDINGS

- The TCO has an exceptionally broad mandate that includes performing open-ended searches across operational capability gaps and technology solutions. This calls for tools and methods different from those used by other DAF and DoD organizations.
- Some data sources for capability gaps are widely referenced, but they are not centrally managed. Data sources for science and technology (S&T) solutions are far more varied and diverse. The volume of data contained across these sources is vast.
- No software tools are systematically used to parse, extract, and summarize the content of capability gap and technology solution sources.
- Modern data science techniques can be used to extract information from free-text descriptions contained in these sources.
- Development planning is a human-centered endeavor that depends on domain knowledge, creativity, and social networks.
- Foresight methods can be used to leverage human expertise and creativity.
- Data science techniques and foresight methods can be integrated to form an HCDE decisionmaking process that involves
  - using data science methods to extract an initial set of capability gaps from data sources that contain formal guidance and/or operational experiences
  - using human-centered methods to iterate the selection of capability gaps and to enrich their descriptions
  - using data science methods to extract an initial set of technology solutions from S&T sources
  - reiterating with human-centered methods to determine the final technology solution set to be proposed.

RECOMMENDATIONS

- The AFRL and the TCO should use the concept development and selection process described above.
- The AFRL and the TCO should use a software tool, like the one described in this report, to extract information from natural language data sources. As they do so, they should conduct user testing and validation studies to improve the software tool.
- The AFRL should explore alternate NLP methods to maximize the utility of information extracted from free-text sources.
- The DAF should curate and standardize key operational capability gap data sources.
- The AFRL, the DAF, and the TCO should enrich key S&T data sources by purchasing or developing capabilities to cleanse records and merge them with metadata.
- The TCO should expand the use of creative, interactive, expert-driven, and evidence-based foresight methods.
- As a stepping stone to reach full curation and standardization of HCDE capability
- development planning, the AFRL and the TCO should record human-generated
- technology pairings for capability gaps.

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