OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

HFC Proposers' Day
IARPA

LEADING INTELLIGENCE INTEGRATION

Dr. Seth Goldstein

February 3, 2016

Slides that have been revised since 2/3 proposers' day are marked with an asterisk (*)

Agenda

Time	Topic	Speaker
9:00am – 9:15am	Welcome Remarks	Dr. Seth Goldstein Program Manager, IARPA
9:15am – 9:45am	IARPA Overview and Remarks	Dr. Jason Matheny Director, IARPA
9:45am – 10:30am	HFC Program Overview	Dr. Seth Goldstein Program Manager, IARPA
10:30am – 10:45am	Break	
10:45am – 11:15am	Doing Business with IARPA	Mr. Tarek Abboushi IARPA Acquisitions
11:15am – 11:45am	HFC Program Questions & Answers	Dr. Seth Goldstein Program Manager, IARPA
11:45am – 1:00pm	No-Host Lunch	
1:00pm – 2:30pm	5-minute Capability Presentations	Attendees (**No Government**)
2:30pm – 4:00pm	Networking and Teaming Discussions	Attendees (**No Government**)

Proposers' Day Goals

- Familiarize participants with IARPA's interest in research on hybrid forecasting methods.
  - Ask questions and provide feedback; this is your chance to alter the course of events.
- Foster discussion of synergistic capabilities among potential program participants, i.e., facilitate teaming.
  - Take a chance: someone might have a missing piece of your puzzle.

Disclaimer

- This Conference is provided solely for information and planning purposes.
- The Proposers' Day Conference does not constitute a formal solicitation for proposals or proposal abstracts.
- Nothing said at Proposers' Day changes the requirements set forth in a BAA.

Schedule

- Full proposals are due ~45 days after the BAA is published.
- Once BAA is published, questions can only be submitted and answered in writing in accordance with the BAA guidance.

OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

IARPA Overview

Dr. Jason Matheny
Director, IARPA

February 3, 2016

Office of the Director of National Intelligence

IARPA Mission and Method

IARPA's mission is to invest in high-risk/high-payoff research that has the potential to provide the U.S. with an overwhelming intelligence advantage over our future adversaries

- **Bring the best minds to bear on our problems**
  - Full and open competition to the greatest possible extent
  - World-class, rotational, Program Managers
- **Define and execute research programs that:**
  - Have goals that are clear, measurable, ambitious and credible
  - Employ independent and rigorous Test & Evaluation
  - Involve IC partners from inception to finish
  - Run from three to five years

Office of Incisive Analysis

"Maximizing Insight from the Information We Collect, in a Timely Fashion"

Large Data Volumes and Varieties	Social-Cultural and Linguistic Factors	Improving Analytic Processes
Providing powerful new sources of information from massive, noisy data that currently overwhelm analysts.	Analyzing language and speech to produce insights into groups and organizations.	Dramatic enhancements to the analytic process at the individual and group level.

Office of Smart Collection

"Dramatically Improve the Value of Collected Data"

Novel Access

Provide technologies for reaching hard targets in denied areas

Asset Validation and Identity Intelligence

Detect the trustworthiness of others

Advance biometrics in real-world conditions

Tracking and Locating

Accurately locate HF emitters and low-power, moving emitters with a factor of ten improvement in geolocation accuracy

Office of Safe and Secure Operations

"Counter Emerging Adversary Potential to Deny our Ability to Operate Effectively in a Globally-Interdependent and Networked Environment"

Computational Power

Revolutionary advances in science and engineering to solve problems intractable with today's computers

Trustworthy Components

Getting the benefits of leading-edge hardware and software without compromising security

Safe and Secure Systems

Safeguarding mission integrity in a hostile world

Office for Anticipating Surprise

"Detecting and Forecasting Significant Events"

S & T Intelligence

Detecting and forecasting the emergence of new technical capabilities.

Indications & Warnings

Early warning of social and economic crises, disease outbreaks, insider threats, and cyber attacks.

Strategic Forecasting

Probabilistic forecasts of major geopolitical trends and rare events.

How to engage with IARPA

- **Website: www.IARPA.gov**
  - Reach out to us, especially the IARPA PMs. Contact information on the website.
  - Schedule a visit if you are in the DC area or invite us to visit you.

- **Opportunities to Engage**:
  - **Research Programs**
    - Multi-year research funding opportunities on specific topics
    - Proposers' Days are a great opportunity to learn what is coming, and to influence the program
  - **"Seedlings"**
    - Allow you to contact us with your research ideas at any time
    - Funding is typically 9-12 months; IARPA funds to see whether a research program is warranted
    - IARPA periodically updates the topics of interest
  - **Requests for Information (RFIs) and Workshops**
    - Often lead to new research programs, opportunities for you to provide input while IARPA is planning new programs

Concluding Thoughts

- **Our problems are complex and truly multidisciplinary**
- **Technical excellence & technical truth**
  - Scientific Method
  - Peer/independent review
  - Full and open competition
- **We are always looking for outstanding PMs**
- **How to find out more about IARPA**:

  www.IARPA.gov
- **Contact Information**

  Phone: 301-851-7500

OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

HFC
Program Overview

LEADING INTELLIGENCE INTEGRATION

Dr. Seth Goldstein
February 3, 2016

Hybrid Forecasting Competition (HFC) Overview

- HFC is a multi-year research and development program.
- The HFC Program seeks to advance the science and practice of forecasting through the combination and interaction of human- and machine-based forecasting systems (hybrid forecasting methods)
  - Research best approaches to quantitative modeling for forecasting geopolitical and geoeconomic events (at generally the country-month and country-quarter level)
  - Research to determine optimal protocols for humans interacting with machines for purposes of forecasting.
  - Research will drive analytic triage protocols by focusing human attention on the components of forecasting tasks (and on forecasting problems) that are most likely to be efficient uses of time/effort rather than prohibitively difficult or time-consuming.

Background

IARPA's Aggregative Contingent Estimation (ACE) Research Program

- ACE generates accurate, precise, continually updated forecasts on key intelligence questions by "crowdsourcing" the forecasts and experimenting with better ways to elicit and aggregate people's judgments.
- **Team Good Judgment**, led by Philip Tetlock and Barbara Mellers of the University of Pennsylvania, beat benchmark forecasting methods by >50%.
- This is the largest improvement in judgmental forecasting accuracy observed in the literature.

Background and Definitions

- Machine model: A model powered by machine-scraped or collected data (e.g. IARPA Open Source Indicators) or other archival statistical data (e.g. GDP, UN development statistics).
- Machine data: generally textual data or econometric data, generally coded without humans in the loop.
- Human data: human forecasts or metadata derived therefrom; or psychometric data
- Hybrid Method: For instance, any interaction of human forecaster with machine model; human forecasts as inputs into a machine model; machine model input/output data fed to a human forecaster, etc.
  - For purposes of these definitions, we do not consider aggregative models (ACE) or methods to be hybrid methods even though such aggregative models were estimated and tuned using machines (computers).
- Ensemble models: (weighted) averaging of different human- and machine-based tools.

Current Forecasting State of the Art

- Lack of research into optimal mode of human and machine interactions.
- Extant methods generally either exclusively machine-based or human-based.
- Machine-based forecasting systems
  - CIA's Political Instability Task Force (PITF), DoD's Integrated Crisis Early Warning System (ICEWS), IARPA's Open Source Indicators (OSI)
    - PITF: annual forecasts of country-level instability, with ~80% accuracy at two-year lead time. Models use country-level structural data (e.g. political institution type).
    - ICEWS: monthly forecasts of country-level insurgency, political instability, rebellion, and ethnic/religious violence, with 80% accuracy and recall, 70% precision. Models use country-level structural data and news feeds.
    - OSI: daily forecasts of city-level civil unrest with 85% recall, 70% precision, 75% accuracy. Models use >30,000 dynamic feeds.
- Human-based forecasting systems
  - IARPA's Aggregative Contingent Estimation (ACE)
    - ACE: Brier score of ~0.15 (corresponding to an average probability of ~72% for binary events that happen and ~28% for events that don't) on geopolitical events that are 0.5 to 24 months in the future

Related Research

- Most research involving hybrid techniques is not done prospectively, or involves non-forecasting environments.
- Much of it may take place behind proprietary firewalls, limiting the IC's ability to profit from lessons learned.
- Many techniques involve simple ensemble methods, with little basis in theory on what types of interaction between humans and machines result in optimal accuracy.
- Much research on actuarial vs. clinical judgment, but little research on optimal integration of actuarial and judgment-based forecasting methods.

Related Research

- Graefe, Armstrong et al 2010: simple average of political opinion polls, econometric models, and expert predictions; hybrids achieved ~40% error reduction in popular vote prediction when compared with typical single-component forecast on the 1992-2008 US presidential elections.
- Kasparov 2010; Kelly 2014: Two chess amateurs using 3 computers (centaurs) beat Hydra supercomputer, unaided grandmasters, and a computer-assisted grandmaster in a freestyle chess tournament; in another study, Centaurs (computer-assisted humans) won 53/95 (~56%) of games over AI chess engines.
- Grossklags and Schmidt 2003: Hybrid experimental financial markets (populated by bots and humans) were more efficient than human-only markets when humans in the hybrid market were told of the existence of bots; and less efficient than human-only markets when humans were not told of the existence of bots.

Hybrid Forecasting State of Practice

  - Weather forecasters informally combine computer model outputs from physical models of the atmosphere along with their own clinical judgments and other statistical factors to arrive at forecasts.
  - Sports franchises rely on a mixture of human scouting and statistical analyses (e.g. Moneyball) to guide human decisions about player personnel acquisition.
  - Stockbrokers rely on ad-hoc mixes between computer trade guidance and individual human forecasts; human traders trade with algorithmic traders (e.g. bots).
  - Macroeconomists rely on combinations of professional forecaster judgments and autoregressive model output.
- Other fusions between human and machine are also possible.

A Possible Typology of Hybrid Methods

- Between-question hybrids: Varies human or machine use by question type. For question type X, use model M; for question type Y, use human judgments J… Ex: For questions on leadership transition: for quasi-democracies, use simple average of expert predictions; for autocracies, use base-rate model.
- Within-question hybrids: Combine human and machine forecasts into a single forecast. Ex: weighted average of expert macroeconomic forecasts, time-series autoregressive model forecasts.
- Composite hybrids: Contain elements of both between- and within-question hybrids. Ex: For Question type X, human analysts provide forecasts after using input from econometric models of event likelihood; for question type Y, bots will interact with human judgments in a prediction market; for question type Z, use ensemble average between judgments and model output.

Possible Hybrid Forecasting Techniques

- May include, but are not limited to:
  - New event data (machine) models, infused with human judgments
  - Training protocols to be experimentally given to forecasters to train humans to use an appropriate blend of machine models and human judgment
  - Crowdsourced forecasting platform-based (e.g. opinion pools, prediction markets) bots or trading agents that nudge human forecaster judgments towards accuracy
  - Other, more complex schemes for human/machine interaction
  - The analyst will always be in the loop in the IC. Thus HFC-developed methods must employ human forecasters or human-based forecasts.

*HFC Program Scope

- Out of scope:
  - Purely ACE-type aggregative methods that do not involve the infusion of machine data.
  - Machine models with no human forecasts or forecasters in the loop.
  - Simple ensemble methods
  - Techniques devoted to development of falsifiable Individual Forecasting Problems (IFPs)
- Notwithstanding the above, IARPA is agnostic as to the technical methods that may be used to develop the best hybrid methods: indeed, a major goal of the program is to address this as an open research question.

Program Objectives/Test and Evaluation

- IARPA will run a multi-year forecasting tournament.
- Goal: substantially exceed accuracy of current state-of-the-art (e.g. ACE best methods) over 4 years.
- Primary metric will likely be forecast accuracy, as measured by, e.g., mean daily Brier score/mean squared percentage error.
- Other metrics may be included as secondary metrics (e.g. measures of discrimination and calibration).

*Test and Evaluation

- T&E team will track data and method integrity, analyze accuracy of performer hybrid methods relative to a standard human forecasting benchmark: an ACE-like condition, wherein human forecasts are elicited in a crowdsourcing platform and then aggregated.
- The government/T&E team will also make this benchmark data (including both aggregate and anonymized individual-level forecasts) accessible as it is generated, starting in Year 1. Interested teams may leverage the data in model development and testing.
- For Phase 2, Core T&E program evaluation will likely employ a true randomized controlled trial (RCT) framework, wherein a central pool of government-furnished T&E forecasters is used to evaluate developed performer methods.

*Test and Evaluation, ctd.

- In addition to the core program T&E (including the RCT), it is expected that each performer team will pursue an ongoing program of internal research to further develop, pilot, and refine their methods and, more generally, to deepen scientific understanding of the workings, strengths, and weaknesses of the team's technical approach.
- Although this ongoing internal research work may leverage the stream of T&E-furnished benchmark data, performers will be responsible for recruiting and overseeing any other human forecasters needed for ongoing internal research and method refinement. Such recruitment would be needed for any internal studies requiring human-machine interaction (vs. studies where human judgments and machine data are aggregated statistically without the humans interacting with the models)

*Test and Evaluation, ctd.

- Performers must develop models and protocols that deliver forecasts to the government on an automated and continuous basis.
- Forecasting problems may be at monthly, quarterly, or longer time horizons (TBD), and may be drawn from the following topics:
  - macroeconomics (e.g. economic growth rates, inflation)
  - chief executive/national leadership turnover
  - intrastate conflict/domestic instability
  - interstate conflict
  - national/municipal elections (the latter obviously at a sub-national level of analysis)
  - military events (troop deployments, movements, actions)
  - terrorist attacks
  - disease outbreaks/spread
- Forecasting Problems will concern events only in a pre-selected list of countries of geopolitical interest. Unlikely that all event types will be used for every country on the list.

*Test and Evaluation, ctd.

- Number of Individual Forecasting Problems (IFPs): ~350 to 500/year. This is >3x higher than in ACE.
  - Large number will force performers to assess issue of analytic triage—to devise hybrid methods that use human judgments strategically/frugally, force machines to do an appropriate amount of the heavy lifting, and encourage optimal development of hybrid methods that best leverage the unique strengths of humans and machines.
  - Performer teams will likely need to forecast against ≥70% of total IFPs each year; and not <50% in any one subject area. It is also possible there will be no choice in IFP completion.

*Program Schedule

- Current plan: a 48 month effort, in two phases
  - Phase 1 (~15 months)-Internal performer pilot-testing and research; ensure planned methods are viable; Dry-run forecasting on real-world forecasting problems.
  - Phase 2 (~33 months)-Randomized controlled trial to evaluate forecast accuracy from performer tools and protocols; performer internal research continues.
  - Likely that performer teams will be provided with forecasts from human- (ACE-type) and machine-based (ICEWS-type) systems for development of hybrid methods, at IARPA's expense. This provision will begin in phase 1.
    - Teams free to use non-IARPA provided data in construction of HFC methods
  - RCT study with government/T&E forecasters will likely begin in phase 2.

*Phase 1 (~15 months)

- Although it is expected that the government will provide anonymized individual forecaster-level forecasts on all IFPs, performer teams will need to recruit their own human subjects (if applicable based on method) to perform pilot tests and internal research on any methods requiring human interaction with machine methods or data.
- Burn-in forecasting (will likely start in month 10): Piloted methods and models will be dry-run tested by forecasting on real-world events; forecasts on a substantial number of IFPs delivered to T&E team.
- Accuracy scores not likely to be used for formal team evaluation during phase 1.
- Pilot testing of, and experimentation on, hybrid methods will continue in parallel with burn-in forecasting though the remainder of phase 1.

Phase 2 (~33 months)

- Randomized controlled trial (RCT) involving forecasting tournament using developed hybrid techniques.
- Year 2 (starting in month 16): Testing of accuracy of developed methods. Continued research on and refinements of developed methods in preparation for Y3.
- Year 3: Testing of accuracy of methods refined during Y1 of RCT. Continued research on and refinements of developed methods in preparation for Y4.
- Year 4: Testing of accuracy of methods refined during Y2 of RCT. Continued research on and refinements of developed methods. Preparation for final delivery of systems to IARPA.

Team Composition

- Given the combination of technical challenges, we anticipate that teams will possess expertise in:
  - Behavioral and social sciences
  - Mathematics and statistics/econometrics/psychometrics/polimetrics
  - Computer science, computational modelling, crowdsourcing, algorithm development, machine learning,
  - Operational forecasting disciplines (finance, macroeconomics, meteorology)
  - Software rapid prototype development

Teaming

- Because of the many challenges presented by this program, both depth and diversity will be beneficial.
  - Throughput. Consider all that you will need to do, all the ideas you will need to test.
    - Make sure you have enough people and expertise to do the job.
    - Sufficient resources to follow critical path while still exploring alternatives – risk mitigation.
  - Completeness. Teams should not lack any capability necessary for success, e.g. should not rely on enabling technology to be developed elsewhere.
  - Tightly knit teams
    - Clear, strong management, and single point of contact.
    - No loose confederations.
    - Each team member should be contributing significantly to the program goals. Explain why each member is important, i.e., if you didn't have them, what wouldn't get done?

Remember, you may be very accomplished, but can you do it all?

Summary

- HFC seeks to develop methods that combine the best qualities of human- and machine-driven forecasting systems through development of innovative hybrid methods.
- We are looking for well-executed, creative ideas.
- The BAA supersedes anything presented or said at the Proposers' Day.

References

- Graefe, Andreas, et al. "Combining forecasts for US presidential elections: The PollyVote." *Philadelphia: Wharton School. Online: http://marketing. wharton. upenn. edu/documents/research/Pollyvote. pdf* (2010).
- Grossklags, Jens, and Carsten Schmidt. "Artificial Software Agents on Thin Double Auction Markets-A Human Trader Experiment."*Intelligent Agent Technology, 2003. IAT 2003. IEEE/WIC International Conference on*. IEEE, 2003.
- Kasparov, Garry "The Chess Master and the Computer", *New York Times Review of Books*, Feb 11 2010, http://www.nybooks.com/articles/archives/2010/feb/11/the-chess-master-and-the-computer/.
- Kelly, Kevin. "The Future of AI? Helping Human Beings Think Smarter", 3 December 2014, http://www.wired.co.uk/magazine/archive/2014/12/features/brain-power/page/2

Acronyms

- ACE- IARPA Aggregative Contingent Estimation Program
- ICEWS- Integrated Crisis Early Warning System
- IFP- Individual Forecasting Problem
- MDE- Mean Daily Error (discrete events scoring rule)
- MSPE- Mean Squared Percentage Error (continuous events scoring rule)
- OSI- IARPA Open Source Indicators Program
- PITF- Political Instability Task Force

OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

Q&A

LEADING INTELLIGENCE INTEGRATION

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OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

Doing Business with IARPA

Mr. Tarek Abboushi

February 3, 2016

Doing Business with IARPA - Recurring Questions

- Questions and Answers (http://www.iarpa.gov/index.php/faqs)
- Eligibility Info
- Intellectual Property
- Pre-Publication Review
- Preparing the Proposal (Broad Agency Announcement (BAA) Section 4)
  - Electronic Proposal Delivery (https://iarpa-ideas.gov)
- Organizational Conflicts of Interest (http://www.iarpa.gov/index.php/working-with-iarpa/iarpas-approach-to-oci)
- Streamlining the Award Process
  - Accounting system
  - Key Personnel
- IARPA Funds Applied Research
- RECOMMENDATION: Please read the entire BAA

Responding to Q&As

- Please read entire BAA before submitting questions
- Pay attention to Section 4 (Application & Submission Info)
- Read Frequently Asked Questions on the IARPA @

  http://www.iarpa.gov/index.php/faqs
- Send your questions as soon as possible
  - HFC BAA: **dni-iarpa-baa-16-02@iarpa.gov**
  - Write questions as clearly as possible
  - Do NOT include proprietary information

Eligible Applicants

- Collaborative efforts/teaming strongly encouraged
  - Content, communications, networking, and team formation are the responsibility of Proposers
- Foreign organizations and/or individuals may participate
  - Must comply with Non-Disclosure Agreements, Security Regulations, Export Control Laws, etc., as appropriate, as identified in the BAA

Ineligible Organizations

Other Government Agencies, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), and any organizations that have a special relationship with the Government, including access to privileged and/or proprietary information, or access to Government equipment or real property, are not eligible to submit proposals under this BAA or participate as team members under proposals submitted by eligible entities.

Intellectual Property (IP)

- Unless otherwise requested, Government rights for data first produced under IARPA contracts will be UNLIMITED.
- At a minimum, IARPA requires Government Purpose Rights (GPR) for data developed with mixed funding
- Exceptions to GPR
  - State in the proposal any restrictions on deliverables relating to existing materials (data, software, tools, etc.)
- If selected for negotiations, you must provide the terms relating to any restricted data or software, to the Contracting Officer

Pre-Publication Review

- Funded Applied Research efforts, IARPA encourages:
  - Publication for Peer Review of **UNCLASSIFIED** research

- Prior to public release of any work submitted for publication, the Performer will:
  - Provide copies to the IARPA PM and Contracting Officer Representative (COR/COTR)
  - Ensure shared understanding of applied research implications between IARPA and Performers
  - Obtain IARPA PM approval for release

Preparing the Proposal

- Note restrictions in BAA Section 4 on proposal submissions
  - Interested Offerors must register electronically IAW instructions on: **https://iarpa-ideas.gov**
  - Interested Offerors are strongly encouraged to register in IDEAS at least 1 week prior to proposal "Due Date"
  - Offerors must ensure the version submitted to IDEAS is the "Final Version"
  - Classified proposals – Contact IARPA Chief of Security
- BAA format is established to answer most questions
- Check FBO for amendments & IARPA website for Q&As
- BAA Section 5 – Read Evaluation Criteria carefully
  - e.g. "The technical approach is credible, and includes a clear assessment of primary risks and a means to address them"

Preparing the Proposal (BAA Sect 4)

- Read IARPA's Organizational Conflict of Interest (OCI) policy: **http://www.iarpa.gov/index.php/working-with-iarpa/iarpas-approach-to-oci**
- See also eligibility restrictions on use of Federally Funded Research and Development Centers, University Affiliated Research Centers, and other similar organizations that have a special relationship with the Government
  - Focus on possible OCIs of your institution as well as the personnel on your team
  - See Section 4: It specifies the non-Government (e.g. SETA, FFRDC, UARC, etc.) support we will be using. If you have a potential or *perceived* conflict, request waiver as soon as possible

Organizational Conflict of Interest (OCI)

- If a prospective offeror, or any of its proposed subcontractor teammates, believes that a potential conflict of interest exists or may exist (whether organizational or otherwise), the offeror should promptly raise the issue with IARPA and submit a waiver request by e-mail to the mailbox address for this BAA at **dni-iarpa-baa-16-02@iarpa.gov**.
- A potential conflict of interest includes but is not limited to any instance where an offeror, or any of its proposed subcontractor teammates, is providing either scientific, engineering and technical assistance (SETA) or technical consultation to IARPA. In all cases, the offeror shall identify the contract under which the SETA or consultant support is being provided.
- Without a waiver from the IARPA Director, neither an offeror, nor its proposed subcontractor teammates, can simultaneously provide SETA support or technical consultation to IARPA and compete or perform as a Performer under this solicitation.

Streamlining the Award Process

- Cost Proposal – we only need what we ask for in BAA
- Approved accounting system needed for Cost Reimbursable contracts
  - Must be able to accumulate costs on job-order basis
  - DCAA (or cognizant auditor) must approve system
  - See **http://www.dcaa.mil** , "Audit Process Overview - Information for Contractors" under the "Guidance" tab
- Statements of Work (format) may need to be revised
- Key Personnel
  - Expectations of time, note the Evaluation Criteria requiring relevant experience and expertise
- Following selection, Contracting Officer may request your review of subcontractor proposals

IARPA Funding

- IARPA funds Applied Research for the Intelligence Community (IC)
  - IARPA cannot waive the requirements of Export Administrative Regulation (EAR) or International Traffic in Arms Regulation (ITAR)
  - Not subject to DoD funding restrictions for R&D related to overhead rates

- IARPA is not DOD

Disclaimer

- This is Applied Research for the Intelligence Community
- Content of the Final BAA will be specific to this program
  - The Final BAA is being developed
  - Following issuance, look for Amendments and Q&As
  - There will likely be changes
- The information conveyed in this brief and discussion is for planning purposes and is subject to change prior to the release of the Final BAA.

QUESTIONS ?