Analysis of Competing Hypotheses

Analysis of Competing Hypotheses (ACH) is an intelligence analysis method based on evaluating plausible and exclusive hypotheses for a given question. It involves validating or invalidating hypotheses using available information; i.e., observed facts or existing data that essentially represent evidence for or against each hypothesis. Through a logical elimination process, ACH seeks primarily to refute rather than validate hypotheses. In short, it helps select those hypotheses compatible with the available information and retrieve the best possible estimate. ACH resembles Differential Diagnosis (DD) in medicine, whereby a particular disease is distinguished from others presenting some similar clinical symptoms in a patient. ACH enables the user to reduce cognitive bias, notably confirmation bias which compels people to seek evidence confirming their own prejudices. A later version of ACH, aptly named Structured Analysis of Competing Hypotheses (SACH), entails breaking down one complex question into simple questions then conducting a traditional ACH on each of these questions.

APPLICATIONS SCOPE

ACH was developed by Richards Heuer in the Central Intelligence Agency (CIA) during the 1980s to help analysts within the American intelligence community reduce their cognitive biases when dealing with complex issues. The objective is to provide correct explanations of a situation or accurate forecasts for the future. ACH is an eight-step method based on cognitive psychology, decision analysis, and the classical scientific method. The rigor inherently required means this method is appropriate to use in controversial issues for which analysts wish to show the components considered in making judgements. Applicable to diverse problems which may necessitate explaining an actor's decision or making future forecasts, ACH works well when available information is scattered, incomplete, ambiguous or deceptive.

Time frame: The method is appropriate for any time frame, but the longer the time frame, the less confidence one should have in the results of ACH. Actually, ACH's limitations appear in the relative difficulty of the questions asked when using it.

Domain: One of the true strengths of ACH is that it can work in virtually any domain and with virtually any kind of information.

Number of participants: ACH is typically conducted individually or in small groups. Several attempts have been made to make collaborative ACH software for large groups but none of the attempts has been completely successful.

TIME FRAME

Time frame will obviously depend on the nature of the question. More intricate questions will require significantly more time. That said, analysts trained in the method can complete an ACH analysis as quickly as those who use similar but less rigorous methods.

TECHNICAL REQUIREMENTS

While ACH is often completed with the use of specialized software, such software is not necessary. One advantage of ACH is that it can be completed on scratch paper, if need be.

TOOL IMPLEMEN-TATION COSTS

ACH typically costs nothing but time to implement. There are a number of free software packages to help with the analysis and, as noted earlier, ACH can be conducted without using any of them.

BASIC CHECKLIST

- Analysts need to have a working familiarity with ACH or SACH.

- There needs to be a clear requirement. Within intelligence circles, where this method is typically used, the question will be something important to the success or failure of an organization but which lies outside that organization's control.

- Hypotheses to be considered should be mutually exclusive or as close to mutually exclusive as possible. Analysts need to have access to a sufficient body of evidence relevant to the requirement (question) and hypotheses.

RELEVANCE AND USE IN FORESIGHT

There is little literature highlighting ACH's value in foresight, partly due to a difference in objectives and content. Essentially, ACH acts as an estimative tool when considering activities important to the success or failure of an organization but which lie outside of its control. The objective is to eliminate the poor hypotheses and keep the best one. However, in the exploratory phase of a foresight activity, we do the opposite and open up the field of possible futures by formulating various hypotheses and framing contrasted scenarios. The goal is to retain several hypotheses which could be justified by observed or potential phenomena, *e.g.*, weak signals or trends. In addition, as foresight seeks to imagine the unforeseen in order to prepare, it is possible to keep more daring hypotheses.

Most futurists intuitively apply the principles underlying ACH. They compare future hypotheses with measurable phenomena, *e.g.*, long series of data, facts and events. There is an intellectual back and forth among representations (conjectures, hypotheses, scenarios) and realities (facts, events, measurable phenomena) at every stage in foresight. Probably the most obvious foresight examples would be in monitoring key hypotheses and choosing the most plausible scenario.

How to Adapt ACH Tools to Foresight

In today's context of relativism where expertise is questioned, conducting a foresight analysis that uses ACH would enable practitioners to anchor their work in a more scientific basis. This scientific framework would help reduce cognitive biases in the intuitive analysis that occurs through the confirmation hypothesis. Detecting systematically (as in ACH) the phenomena potentially contributing to hypotheses for the future belongs to traditional foresight activities such as horizon-scanning or monitoring. Nonetheless, foresight analyses must also include approaches drawing upon fears, aspirations, motivations and imaginaries, notably in the exploratory phase (the field of possible futures, conjectures, scenarios), plus the input of stakeholders.

The double-entry tables used in ACH that present hypotheses in columns and significant evidence in horizontal rows are easily adapted to foresight analysis. In foresight, hypotheses on the future appear in a column while the phenomena such as real or potential facts appear alongside. The objective is to enrich hypotheses about the future by seeking available data, *e.g.*, phenomena and facts, which broaden the array of possible hypotheses for a question. Entries considered relevant in foresight are those for which representations and realities are compatible.

Using the ACH principles for foresight encourages users to do the following:

— Formulate 2 to 5 contrasted hypotheses; *i.e.*, mutually exclusive hypotheses. If one hypothesis is validated, the others cannot be valid.

— Seek out actively potential phenomena like heavy trends, inertia, seeds of change or actors' ambitions, which could validate or invalidate various hypotheses.

— Update relevant facts, events, data systematically, with respect to selected current or potential phenomena. Strictly speaking, this is scanning/monitoring and often incremental. Updating allows users to confirm or refute the various hypotheses.

— Review how the question under study or hypotheses are worded based on the results generated in the double-entry table. Actually, rewording or reframing the question or hypotheses may be done once a year, unless a major event occurs. This practice resembles the process of users' breaking down a question and formulating new hypotheses, as in an SACH exercise.

More research should be conducted on the connections between ACH and foresight. Links detailed here may serve as suggestions worthy of further study.

TABLE 1. EXAMPLE OF A DOUBLE-ENTRY TABLE ADAPTED FROM ACH TO FORESIGHT		
Question: What Will the Electric Car (e-car) Situation Be in France in 2030?		
Space for representations: contrasted and plausible/probable hypotheses for final situations / **Space for realities: phenomena to monitor**	**Hypothesis 1 with time horizon for the question under study** Fewer than 4 million electric vehicles circulating in France in 2030	**Hypothesis 2 with time horizon for the question under study** At least 15 million electric vehicles circulating in France in 2030
Potential phenomena: • **Heavy trends** • **Seeds of change** • **Actor ambition**	Compatible/ incompatible	Compatible/ incompatible
Relevant events/facts/situations/data in terms of potential phenomena	Compatible/ incompatible	Compatible/ incompatible
Heavy trend — improved battery performance (cost/efficiency)	Compatible	Compatible
Fact — in January 2018, a battery capable of 350 km, priced under 20,000 euros came on the market	Compatible	Compatible
Actor ambition — French government: law on energy transition for green growth (passed August 18, 2015) designed to create 7 million recharging stations throughout France, horizon 2030	Compatible	Incompatible
Actor ambition — French government goal in 2016: 30,000 public charging stations, horizon 2020	Compatible	Incompatible
Revised actor ambition — French government goal in 2017: 100,000 public charging stations and 1 million private chargers for horizon 2020	Compatible	Moderately compatible
2017 situation — 20,000 public charging stations installed; *i.e.*, one charger per 6 electric vehicles	Compatible	Incompatible, unless things speed up considerably
Actor ambition — progressive or definitive prohibition of conventional combustion vehicles in major cities	Compatible	Compatible
Fact — In Paris, the mayor gave 2030 as deadline after which the capital no longer would allow conventional motorized vehicles circulating within city limits. — In Lyon…	Incompatible	Compatible

Source: Futuribles International.

Analysis of Competing Hypotheses

by Kristan Wheaton*

*Kristan J. Wheaton is a professor of intelligence studies at Mercyhurst University in Erie, Pennsylvania. His research interests include redefining and improving the intelligence process, validating intelligence methods and practices, the use of games in teaching intelligence analysis and intelligence support to entrepreneurs. Kris is also the author of *The Warning Solution: Intelligent Analysis in the Age of Information Overload* and *How to Get a Job in Intelligence*, co-author of *Structured Analysis of Competing Hypotheses: Theory and Application* and *Wikis in Intelligence Analysis* and lead author of over 40 articles and publications on intelligence and intelligence analysis. He is the recipient of the CIA Seal Medallion and the State Department's Superior Honor Award and is a member of the South Carolina Bar.

He may be reached at kwheaton@mercyhurst.edu

Abstract

Analysis of Competing Hypotheses (ACH) and Structured Analysis of Competing Hypotheses (SACH) are methodologies designed to reduce the level of uncertainty among decision-makers when analyzing events, organizations or activities outside the decision-makers' control and when the data available is unstructured, incomplete, ambiguous or potentially deceptive. Widely used within the American national security intelligence community, ACH is considered particularly appropriate for intelligence problems. There are other methods analogous to ACH, *e.g.*, the broadly used medical methodology, Differential Diagnosis (DD). SACH is less used but generally considered an improvement on ACH as it simplifies the analytic problem and makes the analyst's reasoning more transparent. Both methods are conceptually straightforward and require no special mathematical or technical knowledge to use, so they are considered particularly appropriate for entry-level analysts.

Both ACH and SACH use matrices to organize information and conclusions about that information. In general, analysts take whatever question that they are trying to answer and develop competing hypotheses for potential answers to that question. Analysts can then test each piece of information regarding the question to determine how consistent it is with each of the competing hypotheses. The hypothesis with the least amount of inconsistent information is generally considered more likely to be correct.

Richards Heuer, a former CIA analyst originally developed the Analysis of Competing Hypotheses (ACH) to help analysts overcome cognitive biases. While experimental evidence on the efficacy of either ACH or SACH remains thin, there is some evidence suggesting that ACH, at least, does mitigate confirmation bias. Evidence suggests that these two methods can modestly improve the accuracy of analysts, particularly entry-level analysts. There is no proof that ACH or SACH diminishes forecasting accuracy. Despite limited scientific studies, there are many good reasons to use ACH/SACH. First, the method imposes a logical structure on arguments and creates a common language among analysts. Second, it captures the analytic process so that it can be reviewed after the fact for potential improvements. Finally, when executed properly, ACH and SACH allow teams of analysts to work much faster by focusing the team's efforts on critical issues and thus allowing the team to produce reports much more quickly. ∎

Keywords

Analysis of Competing Hypotheses ❙ Structured Analysis of Competing Hypotheses ❙ Structured Analytic Techniques ❙ Intelligence Analysis ❙ Analytic Methods ❙ Richards Heuer

Description

In *The Psychology of Intelligence Analysis,* Richards Heuer identified how the human mind gets in the way of accurate forecasts regarding the future. Cognitive biases, for example, are rules of thumb which have been hardwired into the human brain through evolutionary pressures. Like an optical illusion, no matter how much an analyst consciously tries to see past these biases, the unconscious part of the brain continues to assert itself. Indeed, confirmation bias, which encourages us to seek evidence that confirms our pre-existing beliefs, can lead us to fall victim to conspiracy theories. Other cognitive biases can have similar negative effects when forecasting. The wired world of the 21st century, with its lack of filters and editors, only exacerbates this problem.

ACH and its sister method SACH were designed to help analysts overcome the worst of these effects. Built on the scientific method, analysis starts with the assumption that "Analysts are, in effect, choosing among several alternative hypotheses" when answering a question.[1] ACH and SACH both then use matrices to organize information that is relevant to the question and its hypotheses, evaluate that information for its consistency or inconsistency with the hypotheses and, finally, generate a forecast.

Scope of the Approach

ACH and SACH are appropriate for a wide variety of forecasting problems. Either method proves an excellent choice when the information relevant to the problem is ambiguous, incomplete, unstructured or potentially deceptive. ACH and SACH also help when working with inexperienced analysts. The modest improvement in forecasting accuracy generated by these methods makes them inappropriate, however, where the data and the problem allow for more precise methods.

ACH and SACH are typically used by individuals or small groups of analysts. Efforts to create software allowing large groups of analysts to work on a single problem through ACH have thus far met with only limited success.

Prerequisites

Conceptually simple, ACH and SACH do present methodological traps for the unwary. Anyone attempting to use ACH or SACH should have some training beforehand. Likewise, if the analysts using the method are inexperienced, their work should be checked by someone who has more experience with the method. Software programs exist for using ACH and SACH,[2] but it is possible to use either method on scratch paper, flip chart or a white/black board. Perhaps the most important precondition is to develop a clear statement of the question to be answered.

---

1. HEUER Richards, *The Psychology of Intelligence Analysis,* Washington, D.C.: CIA, 1999. URL: https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/art11.html. Accessed May 16, 2018.

2. The most famous of these is the Palo Alto Research Center's (PARC) ACH 2.0.5 software. It is free to download from the website. Heuer, who invented ACH, participated in its development. See Case Study examples and Selective Bibliography.

Step-by-Step Application

Step-by-Step Application of the ACH Method

The steps outlined below are drawn directly from Richards Heuer's *The Psychology of Intelligence Analysis*. However, practical commentary on the steps are derived from the author's 15 plus years of experience using the method.

▶ **Step 1: Identify the possible hypotheses to be considered and use a group of analysts with different perspectives to brainstorm the possibilities.**

Developing hypothetical answers for a question may be fraught with difficulty. Fortunately, within ACH there are a few general guidelines that can help analysts avoid problems like "groupthink". First, generating hypotheses using an effective brainstorming method (such as Nominal Group Technique)[3] and a diverse group of analysts goes a long way toward limiting potential problems.

Second, it is important for the hypotheses generated to compete among themselves as much as possible. How can that be achieved?

Let's imagine an unstable country as an example. When asked, analysts might come up with hypotheses such as "There will be a coup" or "There will be rioting in the streets." Obviously, both hypotheses are usually possible when instability is present. There is a strong chance that the evidence collected will not be adequate to distinguish between the two, making the analysis more rather than less fuzzy. The simple solution to this problem is to make the hypotheses mutually exclusive, such as "There will be a coup" and "There will not be a coup."

▶ **Step 2: Make a list of significant evidence and arguments for and against each hypothesis.**

Heuer uses the word "evidence" in *The Psychology of Intelligence Analysis*, but in the generic rather than legal sense of the word. Furthermore, what counts as evidence in traditional intelligence work includes everything from hearsay and third-party analyses to intercepted transmissions and satellite photographs. Clearly, it is important that analysts understand how to evaluate both the credibility of the sources and relevance of the information to the question and hypotheses. Other questions analysts should consider include:

— If this hypothesis were true, what evidence would I expect to observe?

— If I am not observing evidence of this hypothesis, why not? Is it because the hypothesis is false, because related evidence would not normally be observable, or because it is being concealed? Is it because I have not looked for it?

▶ **Step 3: Prepare a matrix with hypotheses across the top and evidence down the side. Analyze the "diagnosticity" of the evidence and arguments; in other words, identify which items are most helpful in judging the relative likelihood of alternative hypotheses.**

At this point, analysts consider whether each piece of evidence is consistent, inconsistent, or irrelevant with respect to each hypothesis and mark each cell of the matrix accordingly. Notation can be as simple as pluses and minuses, or C for consistent, I for inconsistent, N for neutral, and the NA (Not Applicable).

---

3. DUNNETTE Marvin, CAMPBELL John, and JAASTAD Kay, "The Effect of Group Participation on Brainstorming Effectiveness for Two Industrial Samples", *Journal of Applied Psychology*, 47(1), February 1963, pp. 30-37.

It is worth repeating here that ACH is all about trying to disprove rather than prove hypotheses. In this sense, evidence that is inconsistent with a hypothesis is more important than what is consistent because, in general, the hypothesis with the most inconsistent evidence is the least likely happen. It is important to remember that evidence consistent with both hypotheses has no diagnostic value.

		H: 1	H: 2
		Ghana will expand its mobile coverage beyond the Golden Triangle	Ghana will expand its mobile coverage but not beyond the Golden Triangle
	Weighted Inconsistency Score ⇨	-0.0	-0.0
	Enter Evidence		
E4	The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.	N	N
E3	The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	N	N
E2	Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	N	N
E1	Ghana's mobile market is highly competitive, with four operators offering services.	N	N

FIGURE 1. AN INCOMPLETE ACH MATRIX

(The next step would be to evaluate evidence with respect to its consistency or inconsistency with each of the hypotheses.)

Source: author.

One significant difference between ACH and more traditional applications of the scientific method lies in how it deals with inconsistent evidence. In a controlled experiment, it is often possible for a single piece of inconsistent evidence to rule out a hypothesis. However, this is unlikely with the "squishier" kinds of problems for which ACH is typically used. In the uncontrolled environment of real life, there likely will be some evidence that is inconsistent with some, most or all of the hypotheses under consideration.

Another issue arises with the appropriate definitions of the terms consistent and inconsistent. Again, given the nature of the problems for which ACH is typically used, few pieces of evidence will be wholly consistent or inconsistent with a hypothesis. Normally, the evidence will only tend to undermine or support a given hypothesis. Good practice suggests then to encourage analysts first to focus on whether or not a piece of evidence tends to disprove a hypothesis. This is usually a bit easier to see and is, of course, the more important of the conclusions within the context of ACH. This tactic also helps prevent analysts from overthinking their conclusions about consistency or inconsistency.

◗ **Step 4: Refine the matrix by reconsidering hypotheses.**

The mechanical nature of ACH, *e.g.*, matrices filled with Cs and Is, rows of evidence in spreadsheets, quantitative outcomes in terms of the number of inconsistent pieces of evidence, may encourage analysts to think that ACH is some kind of answer machine that reliably cranks out fine forecasts. Disclaimer: ACH is merely a thinking tool that helps analysts record and examine their thought processes.

In the thought process, Step 4 becomes tremendously important. The goal here is not merely to examine the matrix and determine if the process is being carried out correctly. Instead, it is essential that analysts step back at this point to see if what they are doing makes sense. A quick checklist should suffice.

— Have the hypotheses been worded properly?

— Should hypotheses be combined or eliminated?

— Is the evidence unintentionally one-sided?

— Are there relationships between the individual pieces of evidence that are important to consider?

After all, the goal of Step 4 is to stop and actively think about what the analyst has done and make any necessary changes before proceeding.

▸ Step 5: Draw tentative conclusions about the relative likelihood of each hypothesis. Proceed by trying to disprove hypotheses rather than prove them.

In Step 3, it was important to go across each row of evidence and consider its diagnosticity with respect to each hypothesis; whereas, in Step 5 it is important to travel down each column (each hypothesis) and evaluate the hypothesis regarding the totality of evidence for and against it. Again, the goal here is to disprove hypotheses, thus answer the question, "Which one of these cannot be true?"

A common pitfall in this step is to see a large amount of evidence (relative to the total amount of evidence considered) that is inconsistent with all hypotheses. Inexperienced analysts often want to select mindlessly the hypothesis with the least amount of inconsistent evidence as the most likely outcome. However, if all hypotheses have a large amount of inconsistent evidence relative to the total amount of information available, either there is too much uncertainty still in the problem and additional information collection is warranted or the analyst has followed the process incorrectly.

▸ Step 6: Analyze how sensitive the conclusion is to a few critical items of evidence. Consider the consequences for your analysis if that evidence were wrong, misleading or subject to a different interpretation.

Much like Step 4, Step 6 is largely a sanity check on the entire process. Unlike Step 4, however, the over-riding goal here is to identify which pieces of evidence really drive the analysis and to double-check their validity. Evidence from credible sources with a high degree of relevance and diagnostic value is obviously more important than evidence poorly sourced and only indirectly relevant. It is vital that the analyst pick out these "linchpins" and examine them in some detail.

Here are typical questions that the analyst or team should ask:

— Is it possible that this is the result of deliberate deception?

— If this piece of evidence is true what other things would I expect to see as well?

— Do my key pieces of evidence reflect any underlying assumptions?

— What can I do now to check to see if my assumptions are correct?

ACH may prove most useful when it captures an analyst's thought processes, as it gives the analyst an opportunity to go back and check his or her work. However, this benefit may prove a double-edged sword if it encourages analysts to overthink their reasoning. Standard advice may resemble what many teachers tell students taking standardized tests: Check your work but remember, unless you find an obvious error or stupid mistake, your first answer is probably your best one.

◗ **Step 7: Report conclusions. Discuss the relative likelihood of all the hypotheses, not just the most likely one.**

ACH matrices are rarely transmitted directly to the decision-makers who asked the underlying analytic question. Instead, they are interpreted and a narrative version of the resulting analysis is offered. The risk here is that unclear wording in the narrative will muddy whatever clarity emerged from the ACH process.

It is, therefore, advisable to use a limited set of verbal probability expressions or a numerical range to express the underlying likelihood of various hypotheses. This should be coupled with a clear indication of the linchpin facts supporting a given hypothesis as well as any significant facts that run counter to the prevailing analysis. Finally, analysts should consider and report reasons why they might be wrong and, in the interest of intellectual honesty, report their level of confidence in their own estimate.

◗ **Step 8: Identify milestones for future observation that may indicate events are taking a different course than expected.**

When the analysis has been completed; the results, reported, it may prove useful to write down what the analyst would expect to see in the future if the analysis is correct or not. These milestones are useful both in assessing the accuracy of the analysis and in giving the analyst feedback in order to be able to improve the process.

Step-by-Step Application of the SACH Method

SACH is essentially an iterated version of the ACH process. The goal is to break up a complex question into simpler parts and conduct an ACH on each of the parts. Typically beginning with assumptions, this structured approach allows analysts an opportunity to reuse already collected evidence and to discern more sharply the relationships between the parts of the question and how variations in consistencies and inconsistencies of each individual ACH matrix can impact the analyst's overall confidence in the final answer to the original question.

◗ **Step 1: Test any underlying assumptions using ACH.**

The analyst begins the SACH process by examining the question for any underlying assumptions and then testing those assumptions using ACH. How? Imagine a question such as "Which industries and tribal groups are likely to benefit the most from the recent stabilization of country x's economy". Of course, the underlying assumption here is that country x's economy has, in fact, stabilized. Using the procedures described above, the analyst would construct an ACH matrix using competing hypotheses such as "The economy of country x has stabilized" and "The economy of country x has not stabilized".

◗ **Step 2: Determine whether a preponderance of evidence supports one hypothesis. If not, collect more evidence to close the gap. Draw conclusions from the analysis.**

Even early in the process, there simply may not be enough evidence to eliminate all or some of the competing hypotheses. Should this be the case, the analyst would either need to collect additional relevant data or task assistants or participants with the collection of such data.

Note: There is some subjectivity inherent in this decision. Individual analysts may be more or less comfortable with the same kind and quality of information. It is worth reiterating that ACH and SACH are not answer machines but rather thinking tools. Analysts and their managers should treat them as such.

Once analysts think that they have enough information, they can draw tentative conclusions regarding the analysis. For example, if this analysis indicates that the economy has not stabilized as assumed, it is worth going back to whoever asked the question and then initiating a discussion about the next steps. Clearly, if the analysis has been carried out correctly and the assumption on which the question is based turns out to be invalid, then the method has already proven its merit. Indeed, the formalized assumption check is one way that SACH is an improvement over ACH.

On the other hand, if the analysis suggests that the assumption is sound, then the analyst can proceed to increase the complexity of the hypotheses and begin to answer the original question.

▶ Step 3: Duplicate the ACH matrix but remove the diagnosticity evaluations.

The goal here is to have a "clean" matrix that contains all of the data from the previous steps but none of the conclusions about the diagnosticity of the evidence; *i.e.*, the "C's" or "I's" are removed. Since this step will be repeated throughout the SACH process, it is advisable to use an electronic means of organizing the matrix. Some software packages, such as the previously mentioned free PARC 2.0.5 ACH package, include a feature that allows easy duplication of an existing matrix.

▶ Step 4: Break the question into component parts (if possible) and form a set of more detailed hypotheses derived from the previous analysis.

The goal here is to see if the data already collected proves adequate to answer all or part of the main question. For example, the original question "Which industries and tribal groups are likely to benefit the most from the recent stabilization of country x's economy?" highlights two sets of actors, industries and tribal groups. SACH would treat these two groups separately and form hypotheses about each one before testing those hypotheses against existing evidence. For example, given that the assumption check revealed that the evidence did, indeed, support the idea that country x's economy had stabilized, the new hypotheses to be tested against the existing evidence might read something like "Textile industry will benefit" and "Textile industry will not benefit." Similar matrices would be developed for other industries and tribal groups. Once the new hypotheses are developed, it is a simple matter to go through the existing evidence to see what it has to say about each of the new, more nuanced hypotheses.

Note: It is possible to construct these new matrices in ways different from those described above. For example, imagine there are three main industries in country x, automotive, textile and mining. It is certainly acceptable to present each industry as a competing hypothesis in a single matrix instead of treating each industry as its own hypothesis within three different matrices.
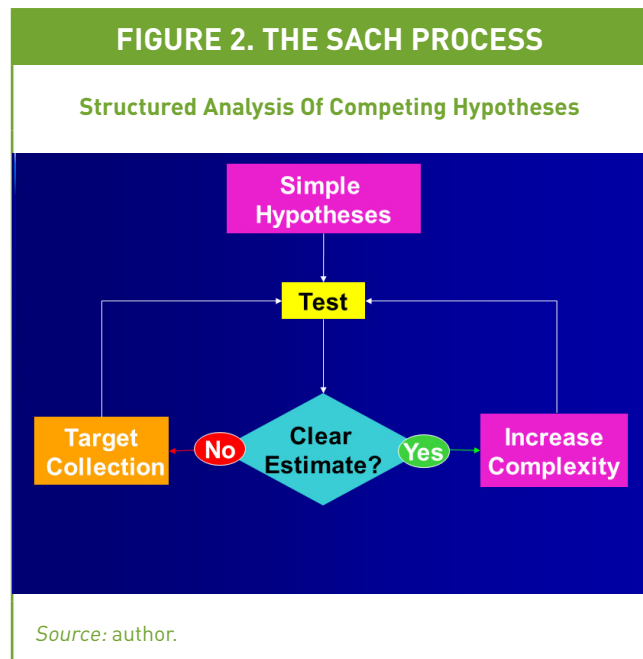
▶ Step 5: Conduct an ACH of the new hypotheses against the old evidence. Collect additional evidence as needed. Draw conclusions. Repeat until the question is fully answered.

This step includes substeps that are repeated as necessary. Analysts easily and frequently get caught up in the process of gathering data at the expense of coming to a conclusion. The SACH method is designed to test new hypotheses against old data to see if there is indeed enough information to answer a question. In the above example, it is entirely possible that data collected to determine if country x's economy was stable may adequately serve to determine if one or more of the industries in that country will benefit from that stability.

Even if there is insufficient data, going through the data already available puts any analyst in a better position to conduct a more focused search or to task more efficiently any participants or assistants with additional research. Once the new data are entered into the matrix, the analyst is prepared to complete the ACH process for this iteration of the SACH process and then draw conclusions.

If the question has not been answered completely, then the analyst can alter the hypotheses once again to target another part of the question, test these new hypotheses against this previously gathered information, collect additional information as needed and then draw new conclusions.

It is worth noting two artifacts of this process. First, as the list of evidence grows, it is highly likely that much of the evidence in the matrix is simply not applicable to the hypotheses currently under consideration. This is normal. Second, the upside to collecting this large body of evidence is that the range of possible questions expands along with the data making it easier to achieve nuanced and well-supported analytic forecasts in significantly less time.

FIGURE 2. THE SACH PROCESS

Structured Analysis Of Competing Hypotheses

Source: author.

Tips and Best Practices

◗ "Train the process". ACH and SACH are conceptually simple, but the devil is in the details. Training analysts to use the process correctly pays for itself.

◗ Use the audit trail to improve the process. ACH and SACH not only improve forecasts but also capture the analytic process. Examining these records for strengths and weaknesses can lead to significant improvements in analytic performance over time.

◗ Make the analyst responsible for the analysis, not the tool. ACH and SACH should help an analyst think through a problem. The ultimate responsibility for the forecast lies with the analyst, not the tool that helped produce it.

Errors to Avoid

◗ Expect great results from poor evidence. ACH and SACH are only as valuable as the evidence they incorporate.

◗ Underthink or overthink the process! As with many analytic methods, one can be too casual or mechanical in the application of the process. A balanced approach is best.

◗ Use ACH or SACH when objective probabilities are likely close to 51/49%. Experiments have shown that the methods lack the resolution to produce useful forecasts when the odds are about even.

Frequently Asked Questions (FAQs)

◗ **How long does it take to train analysts on the methods?**

It typically takes five to ten hours of training (including three to five exercises) to train analysts to use ACH and SACH adequately. Even after this training, analysts should be supervised by someone with experience in the method until they can reliably replicate the process.

◗ **Can I use this method in my discipline/industry/field of study?**

One strength of ACH and SACH is that they can be used for any question where the data available is unstructured, incomplete, ambiguous or potentially deceptive. These two methods are inappropriate when the data are complete and of high quality and more accurate statistical methods are available.

◗ **How long should it take to complete an analysis using these methods?**

The length of time for each analysis depends on the nature of the question, completeness and availability of the data and skill of the analyst. Time required should decrease, however, as analysts become increasingly used to the process. It is not unusual for teams of analysts cooperating on quite complex problems to be able to generate a quality analysis in a relatively short period of time.

SACH Case Study: Ghana Telecommunications

Note: The following case study conducted for a private client using SACH has been modified to highlight the process. All facts and evidence are for illustrative purposes only.

Imagine that a small team of analysts has been asked to take a look at the telecommunications situation in the country of Ghana in West Africa.

Specifically, the team was asked this question:

"Will the Chinese provide the equipment for the expansion of mobile/cell phone services into rural Ghana?"

Team members know little about telecommunications in Ghana but are quickly able to provide the following details using open sources:

◗ Wireless seems the only realistic solution for phone access in Ghana, where connectivity remains hampered by slow, unreliable landlines, so the country is rapidly shifting towards wireless networks. Four operators are currently offering mobile services in Ghana's highly competitive market.

◗ The country offers great potential for mobile operators as current fixed services are concentrated in the capital and other major cities near the coast (The Golden Triangle) leaving the rural areas, where nearly 70% of the population live, largely neglected.

◗ More mobile, particularly third generation mobile, also implies more fiber optic cable between cities in order to provide a "backbone". While expanding the fiber optic backbone in Ghana does not mean that mobile technology will necessarily follow, mobile technology cannot go easily where there is no fiber to support it. The current coverage of the optical fiber network does not support an expansion of mobile/cell phone technology beyond the Golden Triangle.

Identify Assumptions and Check Them (Steps 1 and 2)

Clearly, the assumption embedded in this question is whether or not Ghana intends to expand its mobile service at all. Formulating relevant hypotheses and utilizing the evidence already gathered in the above three paragraphs generates a matrix similar to Figure 3, seen on p. 14.

FIGURE 3. THE ACH MATRIX WITH ALL AVAILABLE EVIDENCE ENTERED

		H: 1	H: 2
		Ghana will expand its mobile coverage beyond the Golden Triangle	Ghana will expand its mobile coverage but not beyond the Golden Triangle
	Weighted Inconsistency Score ⇨	-0.0	-0.0
	Enter Evidence		
E4	The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.	N	N
E3	The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	N	N
E2	Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	N	N
E1	Ghana's mobile market is highly competitive, with four operators offering services.	N	N

Source: author.

Note: Different analysts might divide differently the evidence seen in the three paragraphs on p. 13.

After some discussion, the team modifies the matrix to take into consideration their evaluation concerning the diagnosticity of the evidence and draws the conclusion that Ghana does intend to expand its mobile services.

FIGURE 4. THE COMPLETED ACH MATRIX

		H: 1	H: 2
		Ghana will expand its mobile coverage	Ghana will not expand its mobile coverage
	Inconsistency Score ⇨	-1	-3
	Enter Evidence		
E4	The current coverage of the optical fiber network does not support an expansion of mobile technology beyond the Golden Triangle.	I	C
E3	The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	C	I
E2	Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	C	I
E1	Ghana's mobile market is highly competitive, with four operators offering services.	C	I

Source: author.

Once again, while all analysts are likely to assess that the assumption is correct; *i.e.,* Ghana will expand its mobile services somewhere within the country, it is possible that different teams might come up with slightly different interpretations regarding the data. It is also possible that different teams would feel more or less comfortable at this point making an analytic judge-

ment based on the limited evidence available. For purposes of this case study, the analysts presumably are willing to make a call at this point based on the evidence so far gathered.

Test the Old Evidence against New Hypotheses (Steps 3 and 4)

Having concluded that Ghana likely will expand its mobile coverage, the next question implied in the previous question is "Where will this expansion take place?"; *i.e.,* within the entirety of the country or only within the "Golden Triangle" of cities near the coast.

Testing these new hypotheses against our current evidence leaves an unclear picture.

FIGURE 5. TESTING OLD EVIDENCE AGAINST A NEW HYPOTHESIS		
(It is entirely possible that the analyst already has enough information to answer this more robust hypothesis.)		
	H: 1	H: 2
	Ghana will expand its mobile coverage beyond the Golden Triangle	Ghana will expand its mobile coverage but not beyond the Golden Triangle
Weighted Inconsistency Score ⇨	-1.0	-1.0
Enter Evidence		
E4 — The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.	I	C
E3 — The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	C	I
E2 — Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	C	C
E1 — Ghana's mobile market is highly competitive, with four operators offering services.	C	C

Source: author.

Based on the team's current evidence, members are unable to draw a conclusion, so they gather additional relevant evidence:

◗ The President of Ghana has tasked the Minister of Communications to speed up the efforts of the Ministry to "wire up" the entire country within the shortest possible time.

◗ The Chinese Premier and the Ghanaian President agreed to a low-interest loan of about 66 million US dollars for a number of projects, including a plan to upgrade Ghana's communications network by increasing phone lines and improving the country's cellular access.

◗ Ghana's number one mobile phone network has relaunched a roadshow with the objective of bringing its services and products closer to customers, particularly those in the rural areas. It has just signed an agreement with a French company to provide new equipment to extend its cellular network in Ghana.

◗ It is the intention of the Government of Ghana to extend the optical fiber network to northern parts of the country, indeed, to have nationwide coverage.

FIGURE 6. WITH NO DEFINITIVE CONCLUSION FROM THE EXISTING EVIDENCE, ADDITIONAL EVIDENCE IS COLLECTED AND ADDED TO THE MATRIX

	Type	Credibility	Relevance	H: 1 Ghana will expand its mobile technology beyond the Golden Triangle.	H: 2 Ghana will expand its mobile technology but not beyond the Golden Triangle.
Inconsistency Score ⇨				-1	-5
Enter Evidence					
It is the intention of GoG to extend the optical fiber network to reach the northern parts of the country and indeed to have nation-wide coverage.	MEDIUM	MEDIUM		C C	I
Areeba, Ghana's number one mobile phone network has re-launched a road show with the objective of bringing its services and products closer to its customers particularly those in the rural areas. Areeba has just signed an agreement with Ericsson to provide new equipment to extend its GSM network in Ghana.	MEDIUM	MEDIUM		C	I
Chinese Premier Wen Jiabao and Ghanian President John Kufuor agreed to a low-interest loan of about US$66 million for a number of projects, including a plan to upgrade Ghana's communications network by increasing phone lines and improving the country's cellular access.	MEDIUM	MEDIUM		C C	I
The President has tasked the Minister of Communications to speed up the efforts of the Ministry "to wire" up the entire country within the shortest possible time.	MEDIUM	MEDIUM		C	I
The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.	MEDIUM	MEDIUM		I	C
The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	MEDIUM	MEDIUM		C	I
Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	MEDIUM	MEDIUM		C	C
Ghana's mobile market is highly competitive, with four operators offering services.	MEDIUM	MEDIUM		C	C

Source: author.

Inserting this evidence into the existing matrix and evaluating it for diagnosticity creates a matrix that looks like the one in Figure 6.

The team comes to the conclusion that Ghana not only intends to extend cellular coverage but also to extend it into the country's rural regions.

Continue until the Question Is Answered Completely (Step 5)

Now the team is ready to address the question of who will provide the equipment for the expansion. Testing the current evidence against new hypotheses yields the matrix in Figure 7.

Clearly the current evidence does not speak to the question of "who". As with previous iterations of the matrix, the team seeks additional relevant data regarding the expansion of mobile services in Ghana with specific information on who will likely provide the equipment. This additional research yields the following insights:

◗ A large Chinese company is the nominated contractor for the fiber optic expansion.

◗ Ghana is to receive its first advanced cellular communications network following a contract signed by Ghana Telecom and China's largest listed telecommunications equipment manufacturer.

◗ Ghana will receive a concessionary loan equivalent to 20 million US dollars from the Chinese Exim Bank to support the National Communication Backbone Infrastructure Project.

Inserting all of this information into the matrix and evaluating it for diagnosticity gives the final result.

FIGURE 7. TEST OLD EVIDENCE AGAINST NEW HYPOTHESIS... AGAIN!

	Type	H: 1	H: 2
		Ghana will expand its mobile technology beyond the Golden Triangle and Chinese companies will be the primary providers of equipment.	Ghana will expand its mobile technology beyond the Golden Triangle but Chinese companies will not be the primary providers of equipment.
Weighted Inconsistency Score ⇨		-1.0	-1.0
Enter Evidence			
It is the intention of the Government of Ghana to extend the optical fiber network to reach the northern parts of the country and indeed to have nation-wide coverage.		C	C
Ghana's number one mobile phone network has re-launched a road show with the objective of bringing its services and products closer to its customers particularly those in the rural areas. Areeba has just signed an agreement with a French Company to provide new equipment to extend its cellular network in Ghana.		I	C
The Chinese Premier and the Ghanaian President agreed to a low-interest loan of about US$66 million for a number of projects, including a plan to upgrade Ghana's communications network by increasing phone lines and improving the country's cellular access.		C	I
The President has tasked the Minister of Communications to speed up the efforts of the Ministry "to wire" up the entire country within the shortest possible time.		C	C
The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.		NA	NA
The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.		C	C
Mobile lines outnumber fixed seven to one and the demand for mobile is growing.		C	C
Ghana's mobile market is highly competitive, with four operators offering services.		C	C

Source: author.

Translate Results of the Analysis for the Decision-makers Who Asked the Question (Step 5 – Continued)

Communicating the results of this type of analysis to the decision-makers who requested it is yet another skill necessary for a successful analyst. Here, the team translated its results into the following message:

"It is likely that Ghana will expand its mobile services beyond the Golden Triangle and that China will be the primary supplier of the equipment necessary to do so. A large Chinese company is already working on the fiber optic expansion necessary to expand cellular services and the Chinese government has already provided significant loans to Ghana complete the expansion. These loans and bilateral cooperation dwarf the efforts of the only other identified foreign equipment manufacturer in Ghana."

As events develop in Ghana, the team would be able to revisit the analysis to see if their conclusions and their evaluation of the evidence was turning out as expected. This in turn, would lead the team to either reinforce good practices or eliminate bad ones, netting an improvement in forecasting accuracy over time.

FIGURE 8. ADDITIONAL EVIDENCE IS COLLECTED AND ADDED TO THE MATRIX TO CREATE AN AUDITABLE LOGIC CHAIN

		H: 1	H: 2
		Ghana will expand its mobile technology beyond the Golden Triangle and Chinese companies will be the primary providers of equipment.	Ghana will expand its mobile technology beyond the Golden Triangle but Chinese companies will not be the primary providers of equipment.
	Inconsistency Score ⇨	-1	-5
	Enter Evidence		
E9	A large Chinese company is the nominated contractor for the fiber optic expansion.	C C	I I
E11	Ghana would receive a concessionary loan of 20 million dollars from the Chinese Exim Bank to support the National Communication Backbone Infrastructure Project.	C C	I
E10	Ghana is to receive its first advanced cellular communications network following a contract signed by Ghana Telecom and China's largest listed telecommunications equipment manufacturer.	C C	I
E7	Ghana's number one mobile phone network has re-launched a road show with the objective of bringing its services and products closer to its customers particularly those in the rural areas. It just signed an agreement with a French company to provide new equipment to extend the cellular network in Ghana.	I	C
E6	The CHinese Premier and Ghanaian President agreed to a low-interest loan of about US$66 million for a number of projects, including a plan to upgrade Ghana's communications network by increasing phone lines and improving the country's Internet-access.	C	I
E8	It is the intention of GoG to extend the optical fiber network with a National Communication Backbone Infrastructural Project to reach the northern parts of the country and indeed to have nation-wide coverage.	N	N
E5	The President has tasked the Minister of Communications to speed up the efforts of the Ministry "to wire" up the entire country within the shortest possible time.	N	N
E4	The current coverage of the optical fiber network does not support an extension of mobile technology beyond the Golden Triangle.	N	N
E3	The country offers great potential for mobile operators as current fixed services are concentrated mainly in the capital, Accra, and other major cities, leaving the rural areas (where around 70% of the population lives) largely neglected.	N	N
E2	Mobile lines outnumber fixed seven to one and the demand for mobile is growing.	N	N
E1	Ghana's mobile market is highly competitive, with four operators offering services.	N	N

Source: author.

Further Reading: Alternative or Complementary Techniques

Scientific Method

ACH and SACH both derive much of their language and all of their logic from the scientific method. The idea of formulating hypotheses and testing them against the evidence gathered is core to both methods.

Differential Diagnosis

Differential Diagnosis is, perhaps, the most commonly used medical analytic procedure. Designed to differentiate diseases with similar symptoms from each other, the process used by doctors bears a striking resemblance to the SACH procedure outlined above.

Multi-criteria Decision-making Models

These models are similar to ACH and SACH in that they both use matrices to organize the information used for analysis. MCDM models are often better than ACH or SACH in that they provide a wider range of options and have been more thoroughly studied.

Repeated Games

Repeated games (a subset of game theory) model the iterative process of ACH and SACH. However, both ACH and SACH lack the mathematical precision and the large body of background research to support them.

Selective Bibliography

Brasfield Andrew, *Forecasting Accuracy and Cognitive Bias in the Analysis of Competing Hypotheses*, Erie, PA: Mercyhurst University, Thesis, May 2009. URL: https://fr.scribd.com/document/35793494/Forecasting-Accuracy-and-Cognitive-Bias-in-the-Analysis-of-Competing-Hypotheses. Accessed May 20, 2018.

Cheikes Brant, *et alii*, "Confirmation Bias in Complex Analyses", Technical Report No. MTR 04B0000017, Bedford, MA: MITRE, October 2004. URL: https://pdfs.semanticscholar.org/7fe4/d4276e683293997f09758c79800787f52doc.pdf. Accessed June 5, 2018.

Chido Diane, and Seward Richard (eds), *Structured Analysis of Competing Hypotheses: Theory and Application*, Erie, PA: Mercyhurst College Institute of Intelligence Studies Press, 2006.

Duncan Kristin, and Wilson Jonathan, "A Multinomial-Dirichlet Model for Analysis of Competing Hypotheses", *Risk Analysis*, 28(6), December 2008, pp. 1699-1709. DOI: https://doi.org/10.1111/j.1539-6924.2008.01139.x

Folker Robert, *Intelligence Analysis in Theater Joint Intelligence Centers: An Experiment in Applying Structured Methods*, Washington, D.C.: Joint Military Intelligence College, Occasional Paper No. 7, January 2000, 50 pp. URL: https://fas.org/irp/eprint/folker.pdf. Accessed May 20, 2018.

HART John, *The Analysis of Competing Hypotheses (ACH) in The Assessment of Chemical Warfare Activities*, Helsinki: National Defense University, Doctoral Dissertation, 2014. URL: https://www.doria.fi/bitstream/handle/10024/102142/Hart%20%28NetFinal%29.pdf?sequence=2. Accessed June 5, 2018.

HEUER Richards, *The Psychology of Intelligence Analysis*, Washington, D.C.: CIA, 1999. URL: https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf. Accessed June 5, 2018.

KAATI Lisa, and SVENSON Pontus, "Analysis of Competing Hypothesis for Investigating Lone Wolf Terrorist", 2011 European Intelligence and Security Informatics Conference, Athens, 2011, pp. 295-299. URL: https://www.foi.se/download/18.3bca00611589ae79878192/1480076487550/FOI-S--3800--SE.pdf. Accessed June 7, 2018.

KARVETSKI Christopher, *et alii*, "Structuring and Analyzing Competing Hypotheses with Bayesian Networks for Intelligence Analysis", *EURO Journal of Decision Processes*, 1(3-4), November 2013, pp. 205-231. URL: https://link.springer.com/content/pdf/10.1007%2Fs40070-013-0001-x.pdf. Accessed June 5, 2018.

MARRIN Stephen, "Intelligence Analysis: Structured Methods or Intuition?", *American Intelligence Journal*, 25(1), Summer 2007, pp. 7-10. URL: https://fr.scribd.com/doc/48430001/Marrin-Intelligence-Analysis-Structured-Methods-or-Intuition-AIJ-2007-5. Accessed June 7, 2018.

MURUKANNAIAH Pradeep, *et alii*, "Resolving Goal Conflicts via Argumentation-Based Analysis of Competing Hypotheses", 2015 IEEE (Institute of Electrical and Electronics Engineers) 23rd International Requirements Engineering Conference (RE), Ottawa, 2015, pp. 156-165. DOI: https://doi.org/10.1109/RE.2015.7320418

PENNINGTON Jeremy Lee, *Measuring Evidence During Criminal Defense Investigations Through Analysis of Competing Hypotheses (ACH)*, SSRN (Social Science Research Network), December 2012. DOI: https://dx.doi.org/10.2139/ssrn.2187965. Accessed May 20, 2018.

PHERSON Randolph, "The Five Habits of the Master Thinker", *Journal of Strategic Security*, 6(3), Fall 2013, pp. 54-60. URL: http://www.pherson.org/wp-content/uploads/2013/06/The-Five-Habits-Article.pdf. Accessed June 6, 2018

POPE Simon, and JØSANG Audun, *Analysis of Competing Hypotheses using Subjective Logic, CRC for Enterprise Distributed Systems Technology,* University of Queensland, June 2005. URL: http://www.dtic.mil/get-tr-doc/pdf?AD=ADA463907. Accessed May 20, 2018.

SCHOLTZ Jean, *Analysis of Competing Hypotheses Evaluation (PARC),* Gaithersburg, MD: National Institute of Standards and Technology, 2004 (Unpublished Report).

VALTORTA Marco, *et alii*, "Extending Heuer's Analysis of Competing Hypotheses Method to Support Complex Decision Analysis", International Conference on Intelligence Analysis Methods and Tools, McLean, VA: MITRE, May 2005. URL: https://cse.sc.edu/~mgv/reports/TR2005-01.pdf. Accessed June 6, 2018.

WRIGHT William, *et alii*, "The Sandbox for Analysis: Concepts and Methods", *in* Rebecca GRINTER, and Thomas RODDEN (eds), *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI 2006, Montreal), April 2006, pp. 801-810. DOI: https://doi.org/10.1145/1124772.1124890

WHEATON Kristan J., and CHIDO Diane, "Structured Analysis of Competing Hypotheses: Improving a Tested Intelligence Methodology", *Competitive Intelligence Magazine*, November-December 2006.

Tools, Tutorials, Critiques and Case Studies

"Structured Analysis of Competing Hypotheses Interactive Tutorial", National Foreign Language Center. URL: http://www.nflc.umd.edu/projects/non_language/sach. Accessed May 7, 2018.

"A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis", US Central Intelligence Agency, March 2009. URL: http://analytics.typepad.com/files/tradecraftprimer-apr09-1.pdf. Accessed May 7, 2018.

AMADO Rafael, "WannaCry: An Analysis of Competing Hypotheses", May 18, 2017, is a case study of the WannaCry ransomware by Digital Shadows using ACH. URL: https://www.digitalshadows.com/blog-and-research/wannacry-an-analysis-of-competing-hypotheses/. Accessed May 7, 2018.

PHERSON Randy, "How Tight Is Trump with Russia? Use Analysis of Competing Hypotheses to Decide", is a case study of Trump's Russian connections by Globalytica using ACH. URL: http://www.globalytica.com/tight-trump-russia-analysis-competing-hypotheses-decide/. Accessed May 9, 2018.

"DC Sniper: Analysis of Competing Hypothesis I", is a case study of the DC Sniper case using ACH by Pennsylvania State University. URL: https://www.e-education.psu.edu/geog885/l6_p5.html. Accessed May 7, 2018.

"ACH2.0.5 Download Page" (Palo Alto Research Center) is the free software used to generate the ACH matrices in this article. URL: http://www2.parc.com/istl/projects/ach/ach.html. Accessed May 7, 2018.

The ACH Project is free, open source enterprise software for conducting collaborative ACH. The site contains links to the software and to GitHub where the software has a permanent residence. URL: http://competinghypotheses.org/. Accessed May 7, 2018.

"Free Google Spreadsheet ACH Template!" is a free-to-copy spreadsheet that allows you to do ACH using Google spreadsheets. URL: http://sourcesandmethods.blogspot.com/2017/02/free-google-spreadsheet-ach-template.html. Accessed May 9, 2018.

Ongoing Research

RIEBER Steven, "CREATE (CRowdsourcing Evidence, Argumentation, Thinking and Evaluation)" is an IARPA funded research project to look into, among other things, the validity of methods such as ACH. URL: http://c4i.gmu.edu/wp-content/uploads/AFCEA-gmkuk-2016-Rieber.pdf. Accessed May 9, 2018.

"Assessment and Communication of Uncertainty in Intelligence to Support Decision-making" is a NATO Research Task Group looking at human judgement and decision-making in defense and security issues. URL: https://www.researchgate.net/project/Assessment-and-Communication-of-Uncertainty-in-Intelligence-to-Support-Decision-making-SAS-114. Accessed May 9, 2018. ■