AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

HUMAN NATIVE FORM:
A SIMPLIFYING THEORY FOR THE INFORMATION AGE

by

C. Christian Lowry, Major, USAF

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements for the Degree of

MASTER OF OPERATIONAL ARTS AND SCIENCES

Advisor: Lt Col Peter Garretson, USAF

Maxwell Air Force Base, Alabama

April 2018

Disclaimer

The views expressed in this academic research paper are those of the author(s) and do not reflect the official policy or position of the US government or the Department of Defense. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Abstract

Human Native Form (HNF) is a simplifying theory. It posits that by importing data from non-sensory sources, and translating the data into information in a way our mind can intuitively, or natively, absorb and use, we decrease our cognitive load while gaining access to information not otherwise available. It turns data into a form of information that humans can consume. HNF theory posits that people perceive the environment through their senses and process the sensations to produce useable information. This bypasses the need to translate data into information through cognition. HNF presents information instead of data, which reduces cognitive load and increases available working memory, while providing more information to the user; thus, allowing better informed decisions, and faster, more decisive actions.

This paper documents the demonstration of a heads-up display (HUD) device for use by Special Operations Forces (SOF) to provide information according to the HNF approach. It consists of three parts. The first part defines HNF information absorption and discusses the necessity for this unifying theory, creating a new taxonomy for the information age. The second part offers a thought-piece, supported by research, which envisions SOF operations in 2058. The final part provides an after-action report of a three-day hack-a-thon that built the SOF HUD, an augmented reality device from commercial, off-the-shelf technology for augmented reality.

Contents

Human Native Form Introduced

Technology pervades every aspect of our existence, and yet it can isolate us from our environment, causing disconnects between people and their environment. These disconnects skew our perception of events and can make us less effective. For example, GPS-guided moving maps in automobiles, and on cell phones, have become ubiquitous but they can divert attention from driving to map reading, and therefore, disconnect the driver from self-consciousness in driving. While technology promotes human progress, to serve people effectively, *technology must be adapted to how humans function.* By adapting technology to how humankind *prefers* to operate (mentally and biologically), we can correct this disconnect. Thus, a new way to manage technological/human inclusion is needed to replace industrial age thinking/models where humans accommodate technology rather than exploiting technology and scaling it to how humans most effectively function. Human Native Form (HNF) accomplishes this. HNF is a simplifying theory. It posits that by importing data from non-sensory sources and translating the data into information in a way our mind can intuitively, or natively, absorb and use we decrease cognitive load and while gaining access to information that would not be available otherwise. It turns data into information that humans are built to consume. HNF theory posits that humans perceive the environment through senses and process the sense natively, producing useable information. This bypasses the need to translate data into information through cognition. HNF presents information instead of data, which decreases cognitive load and increases available working memory while providing more information to the user; thus, allowing better informed decisions and faster, more decisive actions.

HNF is a shift in thinking but at root a simple concept with even more simple application. For example, a holographic blue line superimposed into your vision guiding you to a restaurant is

an elementary presentation of otherwise unavailable information into HNF. The blue line translates your present position and the restaurant's location into a visual depiction of the most efficient route that requires little thought to follow. Even this simple use of HNF dramatically increases the amount of information we can process and act on by translating information from non-sensory sources into stimulus that human beings process naturally, or natively. Translating data into usable information by exploiting HNF dramatically increases our ability to think critically by reducing cognitive load, freeing working memory, and speeding up decisions. In turn, faster decisions impart an asymmetric advantage to anyone because they can dictate the speed of any action and shape events forcing others to respond. Simply stated: HNF provides consumable information intuitively, eliminating many disconnects we currently experience with technology. HNF is a break from industrial age methodology and thinking. Therefore, it is best understood by first showing how the industrial age changed how humans approach technology and why that model needs to be changed.

The first part of this paper discusses early, human centered technology and methods and how industrial age methods forced humans to adapt to technology and changed human culture. This is not a condemnation of technology or the industrial age, far from it. It is merely an acknowledgement that early technology required more from man than it does today. While technology is much more complex, it is also much more interactive and intuitive to use. Thus, a brief look at how the industrial age formed our culture and the implications for an early information age society still struggling with industrial age culture and antecedents begins the paper. Next, we look at the transition from the industrialization age to the industrial age using agriculture as the example. I posit that technology is enabling the information age, but human society remains linked to the industrial age because of cultural inertia. I then discuss the raw material of the industrial age, data, to draw a distinction between data and information and move

on to discussing the implications of too much data and the need for a unifying principle that allows data to be processed into information and then presented in a native format for humans. Finally, I end the paper with a thought piece on how HNF might shape warfare in the near future. I have also, attached, as an appendix, the after-action report on a hack-a-thon where programmers and military subject matter experts developed the initial demonstrator of the SOF HUD.

II. Early Technology and Change: Human Scaled Production to an Industrial Age Model:

To frame the case for adopting HNF, we must understand its antecedent: industrial age thinking and systems. To facilitate this understanding a short treatment of pre-industrialization and industrialization is required. Once we frame those we can then look at what we mean specifically by post industrialization or information age systems and thinking.

One of the key characteristics that separates human beings from other species is our ability to modify our environment in ways that benefits us. We create tools to accomplish this. We have surrounded ourselves with useful technology throughout our history; this has not changed. What changed is the complexity and pervasiveness of technology and how we integrate it into our daily existence. Before the industrial revolution, technologies were simple by necessity and thus elegant; they solved problems on a human scale. To illustrate what is meant by solving on a human scale consider the problem of elevation and inclines as obstacles to movement. Simple technology in the form of stairs, ramps and ladders surmounted this problem. By using these devices humans could build in places that were formerly difficult, or impossible to use. The ancient architectural wonder of Machu Picchu in Peru would never have been built without the use of humble ladders or stairs. These technological solutions are so much a part of our experience that it is strange to even think of them as technology or solutions to a problem. Clothes are another technology that we tend to take for granted, but without them life would not be possible in many of the climates humans occupy and thrive in. Technology in this age focused

their scope on immediate needs and often dealt with changing the environment to suit human activity. This is a constituent difference in human development; we change our environment more than we adapt to it. This forms one of the guiding principles of HNF: Technology should be adapted or created around human needs and how we prefer to exist. HNF holds technology should not require special training to use.

Early pre-industrial age technologies are in marked contrast with industrial age technology that did not require humans to adapt. Stairs use is intuitive and enhances our ability to walk up inclines, while clothes augment our ability to regulate body temperature. The industrial age built on earlier technologies and shifted focus from accommodating human activity to production in support of human consumption. For example, producing textiles enables more efficient manufacture of clothing making them more available for the consumer and was, thus, a huge driver in ushering in the industrial age. Before production was focused in large factories, weaving was a cottage industry. Wives and children, typically, would process raw materials to make cloth for family use. While there were notable centers of fine cloth production (i.e. Flanders and England) most cloth was homespun and humble. As men designed machines powered by water or steam, the textile industry grew in output and importance, and entrepreneurs built factories. The demand for textiles created a need for efficiencies to increase production scale. Complex machines enabled production by at every stage of production. Technology was developed to plant seeds, harvest crops, separate usable fiber from waste, spin it to yarn or thread, and to finally weave it into cloth. These machines greatly speeded up production of cloth but because of technological limitations required humans to accommodate machinery.

Labor was also industrialized during this period to accommodate these new technologies. A brief look at child labor demonstrates this point. Prior to the industrialization of the economy child labor was primarily confined to family farms and businesses. This was due to the so-called

"Yeoman Ideal"—families were a unit where children and adults alike shared in either prosperity or privation, thus labor was a family endeavor and considered education and necessary vocational training for the families' continued livelihood.[1] This was reinforced in the US by westward settlement and pioneer families until the 1890s when maifest destiny was realized and Americans populated the entire continent.[2] In addition to family labor, pre-industrialized trades depended on apprenticing and indentured servitude. Rather than being a source of social woe, apprenticing increased oppurtunities for social mobility. Childern were apprenticed to a skilled master who taught them their trade and sponsored them as they started out on their own as part of the skilled labor class.[3] This system ensured both labor to skilled workers and an increase in skilled labor. The industrial revolution changed this.

The nature of labor changed dramaticly when industrialization began supplanting traditional means of production. Expanded production in factories demanded labor, and during the transition from traditional skilled production to factory production children and women were readily available because of displacement from traditional occupations. As farms became increasingly dependent on industrial methods of growing crops, children were freed from the necessity of being full time farm laborers, and could be hired out in other capacities; and textiles were being produced in factories faster and cheap enough to reduce the need for homespun fabrics. Thus, women and children were freed from their traditional occupations and became available to run factory equipment. The equipment was not developed with this labor force in mind, and so the labor force was forced to adapt to the technology they were employed to run.

Their small stature made children perfectly sized to crawl around and under weaving machines to clean out flammable lint buildup that was an ever present fire hazard, and by including them in the factory system their mothers were freed from having to watch them and could, thus, join the labor force. This was a huge alteration of social and economic realities of

this time and led to a new way for humans to interact with the world. In fact, industrialized states

populations were deliberately developed to prepare them for inclusion in the industrialized world.

Wages replaced home based production and self-sufficiency in a family's economy during

this time. Labor was focused on production for markets rather than production for consumption.

Consumption was encouraged as the engine to drive demand for the goods industry was

producing. Thus, labor became a commodity, and a free market was developed to support

movement of this commodity. Wages were the means to facilitate consumption and as people

had to compete for jobs by developing the skills necessary to land these increasingly complex

jobs.[4] Child labor could simply not compete in this environment and so education focused on

preparation for joining an industrialized labor market. This profoundly impacted society as

education became focused on producing a labor force adapted to the industrial age.

In the early days of the industrial revolution, Sir William Petty, a British economist,

opined the quality of a nation's labor force indicates the wealth of that nation.[5] Education was

key to improving the quality of a nation's labor force and any exertion in improving education

was really an attempt at improving your state's economic position. Adam Smith's *Wealth of*

Nations adds

> A man educated at the expense of much labor and time to any of those employments
> which require extraordinary dexterity and skill, may be compared to an expensive
> machine. The work which he learns to perform, it must be expected over and above the
> usual wages of common labor, will replace to him the whole expense of his education,
> with at least the ordinary profits of an equally valuable capital.[6]

Because labor was commodified with the advent of the free labor market, children were

no longer competitive as workers. Education was considered an investment to improve future

production, and so it was logical to create an education system that would prepare the next

laborers for their future vocations. Thus, education was industrialized along with industry and

agriculture. The education system was set up to mirror the factory system. Bells called both

students and workers to their classrooms or work station, respectively. Early education put

obedience to hierarchy on equal footing with gaining skills and knowledge. This was all to better

equip future laborers with the required skills for work. Under the industrial age model education's

primary use is to "equip people with the skills that make them more productive in their work.",

further it "enables a nation's people to generate and adopt the new ideas that spur innovation and

technological progress and thereby ensure future prosperity."[7] Thus, the industrial age changed

human society in fundamental ways. It moved production from a human scale to one of mass

production. Education was overhauled to groom industrial age workers. Success was measured

not in development of people's abilities but in production and gross domestic product (GDP). In

fact, educational success was measured by correlating standardized testing to GDP.[8] Rather than

trying to refute the correlation, I will simply state that this is very industrialized way of looking at

education: increased knowledge input will equal increased product output, but it did indelibly

inform the thinking of several generations. Innovation was sought to improve production and

efficiency, but as a side effect seems to have also increased human cognitive growth by offsetting

demands of time and allowing focused mental development throughout the formative years of

childhood to early adulthood.

Because our educational foundation is so heavily informed by industrial age models and

thinking it is difficult to picture what an information age model really looks like. In fact there is

no agreement on what an information age education model looks like, and this deficiency must be

rectified if we are to continue forward as a society in a deliberate way. The next section will look

at literature on information age models and try to delineate between a true information age way of

thinking and an industrial age model with technology applied in novel ways. It begs the question,

"are the two exclusive, and if so what can we do to bridge over to a true information age model?"

III. From an Industrial Age Model to Information Age Reality:

It would be absurd to say the industrial age did not supplant the agricultural age, just as it would be silly to say that the information age will not supplant the industrial age. It would be equally absurd to say that agricultural was wiped out by the industrial age. In fact, as the example of the industrialization of textiles makes clear, the industrial age *fundamentally changed the agricultural age.* Agricultural was industrialized allowing crop production to dramatically increase and free up human labor. Industrialization of agricultural replaced human labor with machines, increased efficacy, and produced more crops per acre. According to Alec Ross, considered one of the nation's leading thinkers on innovation, "Land was the raw material of the agricultural age. Iron was the raw material of the industrial age. Data is the raw material of the information age."[9] We stand at the crossroads of the industrial age and the information age; thus, it bears looking at the change from agricultural age to the industrial age, an earlier crossroads in epochs and what that change meant for human development.

The invention of the iron plow increased acreage under cultivation but increases in crop production per acre from 1500 to 1869 were due to increases in crop yield rather than in improvements in labor output or farming equipment.[10] Professor Gregory Clark's study of the agricultural revolution in England shows that cost of agricultural output was fairly static until the introduction of mechanized tractors and industrialization after 1912. The percentage of funds (adjusted for inflation, etc.) tied up in equipment, or capital, remains fairly level from 1500-1912 (figure 1).[11] In 1830, "about 250-300 labor hours [were] required to produce 100 bushels (5 acres) of wheat [using a] walking plow, brush harrow, hand broadcast of seed, sickle, and flail" by 1850 crop improvements and equipment meant that only 75-90 labors hours were required to produce 100 bushels on only 2.5 acres with the same equipment.[12] This indicates the agricultural revolution was more about improvements in the crops themselves and planting practices rather

than equipment. Production dramatically increased when farmers started using tractors, planters, cultivators and pickers. By 1930 when such industrial practices were the norm a single farmer produced 100 bushels on 2.5 acres with only 9.8 hours of labor.[13] Thus, we see that the agricultural revolution was *augmented rather than replaced* by the industrial revolution. One age simply builds on the other. Thus, the information age is enabled and requires the other ages as antecedents and, furthermore it builds on gains from earlier ages. Continuing our look at agriculture it is manifest that information age practices adopted by agriculture result in unprecedented crop surpluses with relatively little labor.

If you look at data from 1869 to 1930 the yield per acre did not change. It still took 5 acres to grow 100 bushels of wheat and 2.5 acres to grow 100 bushels of corn. Today's agricultural industry is driven by data. Farm equipment requires a large capital investment, but the payoff is a drastic reduction in required labor. Prices for Combines in 2014 ranged from $275,000 to $475,000 but are now tied to a databases that allow more efficient uses data to increase yield while reducing required labor.[14] Using positioning data from the GPS constellation and analysis of each square inch of a field, farmers are beginning to engage in "precision agriculture."[15] According to Ross, precision agriculture will use "real-time data on factors including weather, water and nitrogen levels, air quality, and disease—which are not just specific to each farm acre but specific to each square inch of that farmland. Sensors will line the field and feed dozens of forms of data to the cloud. That data will be combined with data from GPS and weather models. With this data gathered and evaluated, algorithms can generate a precise set of instructions to the farmer about what to do, when and where."[16] Precision agriculture relies on data to increase yield and efficiency. , but this data is only useful if it is translated into usable information. In the case of agriculture data enables precision agriculture and all the benefits

Figure 1

promised by its adoption. The key takeaway is that moving from one age to another is an

additive activity. We must not lose sight of the fact that changes driven by increases in

knowledge and capability should enable rather than restrict. How we characterize these epochs is

important: each age requires a different raw material and thus the epoch can be framed around the

gathering and use of that raw material. In past ages the defining raw material has been a tangible

item, but in the information age it cannot be thought of in tangible terms. If we accept this, then

we must look at the difference between *Data* and *Information*, because they are fundamentally

different, and this will do much to shape the information age. The next section deals with this

issue which allows a fuller discussion and characterization of human native form.

IV. Data is Different than Information:
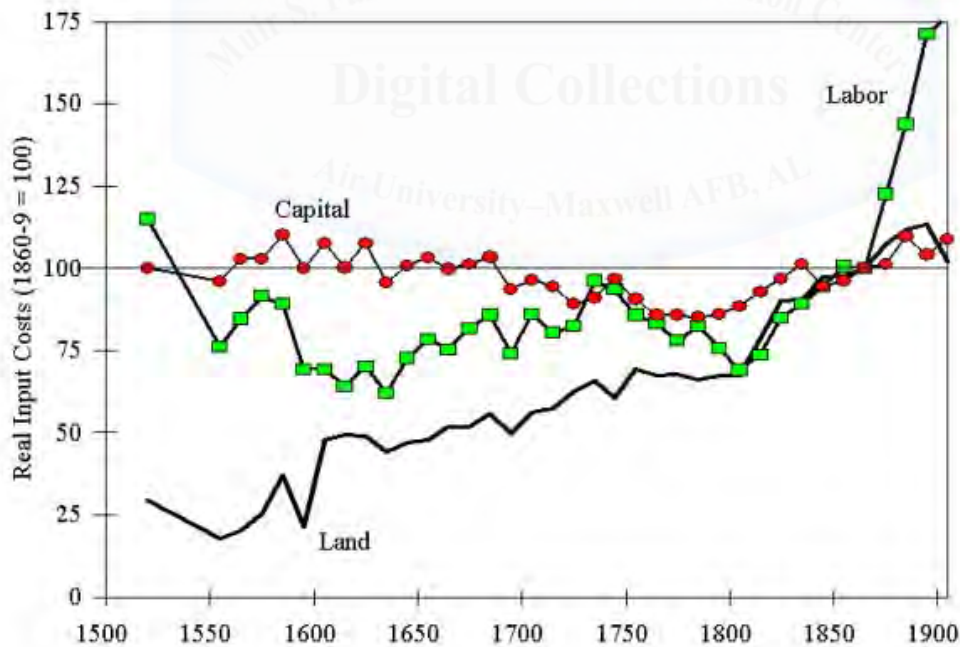
If data serves as the raw material of the information age, then information is the product.

First, an understanding of the semantic difference between data and information. Merriam

Webster defines data as:

1: factual information (such as measurements or statistics) used as a basis for reasoning, discussion, or calculation.
2: information in digital form that can be transmitted or processed.
3: information output by a sensing device or organ that includes both useful and irrelevant or redundant information and must be processed to be meaningful.[17]

Notice how untwined it uses the terms data and information. This signifies the common difficulty in creating a common lexicon necessary for new uses of ideas. Up until the dawn of the information age the old lexicon sufficed, but in the information age the old meanings and emotive response to certain words hinder discourse. Data conceived as a selection of facts that that "must be processed to be meaningful" begs the question of "how do you process data to make it meaningful." This question helps reveal the larger problem. Richard Leghorn, who founded the Itek Corporation, coined the term "information age" in 1960. He also served as the Department of Defense's Chief of Intelligence and Reconnaissance Systems Development. He used the term in a sentence, but felt it would not serve adequately over long term: "Present and anticipated spectacular informational achievements will usher in public recognition of the *information age*, probably under a more symbolic title."[18] While the term did catch on, as a commonly used term it does little to shape the age due to its past usage.

In 2010 the *Oxford English Dictionary* updated its entry for the term. Its entry now runs over 9,400 words, or roughly 39 pages![19] This massive update recasts the word in its new role as the title of an age. The first recorded use of the term in English deals with legal proceedings— "The earliest citation comes from the Rolls of Parliament for 1386: 'Thanne were such proclamacions made..bi suggestion & informacion of suche that wolde nought her falsnesse had be knowen to owre lige Lorde.'"[20] In this usage it is more akin to data, a simple recitation of purported facts. Here is the root of the confusion in semantics: it once meant the same as data, yet it developed into a more nuanced word. In common usage it came to mean teaching or passing on knowledge. The two meanings were more than adequate throughout the agricultural

and industrial ages when the majority of education was instruction based and most students were

merely expected to engage in rote memorization of facts.[21] Rote memorization of facts is useful

for factory workers. A well-trained work force needs the ability to gain, hold, and recall facts,

but a truly educated force must be able to understand underlying principles, analyze current

states, and then synthesize new principles. These requirements of the information age points us

to the Latin root: *informare*—to shape, to mold or give form to.[22]

The human brain performs this shaping or molding by cognition rather than a simple

recitation of facts. As author and science historian James Glieck puts it, "Our minds are

informed; then we have something we lacked before—some idea, some knowledge, some

information."[23] Rather than try to distill the *Oxford English Dictionary*'s 39 pages, *Merriam-*

Webster's Dictionary offers a much more succinct definition:

> 1: the communication or reception of knowledge or intelligence
> 2 a (1): knowledge obtained from investigation, study, or instruction (2): intelligence, news (3): facts, data
>> B: the attribute inherent in and communicated by one of two or more alternative sequences or arrangements of something (such as nucleotides in DNA or binary digits in a computer program) that produce specific effects
>> C: (1): a signal or character (as in a communication system or computer) representing data (2): something (such as a message, experimental data, or a picture) which justifies change in a construct (such as a plan or theory) that represents physical or mental experience or another construct
>> D: a quantitative measure of the content of information; specifically: a numerical quantity that measures the uncertainty in the outcome of an experiment to be performed.[24]

If we accept this definition it becomes very clear that *information is derived from processed data*

which informs decisions that enable actions. Thus, the vital key to correct action resides in how

we process data into information correctly.

V: The Utility of Information vs. Data:

All action is based on information, and the quality of information dictates how successful an action is. This is true for a nation's strategic posture, an army's tactical movement, or how a company launches a new product. If a nation adopts a grand strategy based on faulty information (usually caused by misinterpretation or incorrect processing of data) it creates the conditions for a catastrophic failure. An example of this is Hitler's war of choice with the Soviet Union during World War II. Had he not preemptively invaded Russia the Nazi's might have been able to consolidate their gains in East and Western Europe. Because the Nazi's misinterpreted their intelligence data and misread the political situation, Hitler was given information that indicated a preemptive war with Russia would eliminate a threat before it could materialize. Nazi Germany did not violate the rational actor model at all. They made a calculated decision based on information that indicated the best course of action involved invading the Soviet Union. The failure was not in decision making, rather the failure stemmed from using data incorrectly and producing faulty information on which to base the decision. Thus, the decision to invade was not wrong, given the information, even if it led to the demise of the Reich. Using data incorrectly is not the only pit fall. Even more dangerous than incorrectly using data is ignoring it because you are overwhelmed by the amount of data available and an inability to process it into information. This is what happened to the Ford Motor Company in the late 1950s with the disastrous Edsel.

In 1957 the Ford Motor Company wanted to capture more of the market share of American automobile sales and so launched a massive research initiative to tell them what type of car the American Public wanted. The result was the ill-fated Edsel which cost Ford over $2 Billion in 2007 dollars.[25] This failure was less about the car and research but what the Edsel design and marketing team did with the data. They had thousands of dollars and hours in market research only to be so overwhelmed with the data that they made decisions based on exasperation

rather than on processed data. For example, Ford hired Columbia University's Bureau of Applied

Social Research to conduct research. Part of that research included coming up with a name that

would appeal to consumers. The research generated a list of 20,000 names. This massive amount

of data was culled down into a list of ten names that were put forward to Ford's Executive

Committee. They rejected each one of these carefully vetted names and decided to name the care

after Edsel Ford at the command of Ford's Chairman Ernest Breech.[26] This decision was not

based on any research. It was a capricious decision made to curry favor with the Ford family.

The head of the marketing team issued a memo "we have just lost 200,000 sales [because of

the name]."[27] We can excuse the Executive Committee for this if we understand that only so

much data can be processed into useable information. Providing a list of 20,000 names has

no utility—one cannot process that much data and make an informed decision, so currying

favor with the boss becomes as attractive a course of action as picking a name. This deluge

of data is a problem that we are familiar with today.

VI: Too Much Data is Just Too Much:

A man dying of thirst has trouble believing that you could have too much water, while a

drowning man needs no convincing of this. In the same way that the drowning man understands

we must understand that too much data is just too much and mostly unusable. The water example

is easy to understand, but when we talk of data it is too easy to scoff at this. "How can we have

too much data? More data helps us make better informed decisions!" This is true to a point. If

we choose to ignore the lessons from the Edsel we only need to look at our fetish, like collection

of intelligence, surveillance and reconnaissance (ISR).

Our use of networked warfare is a quest to integrate useable information on the battlefield

to give ourselves a decisive advantage against any opponent. Networked warfare has helped

achieve this against state actors and even assisted our counter-terrorism efforts, but the advent of

persistent ISR has perverted this desire for information. Persistent ISR produces vast amounts of data, but little, or no, information. To avoid conflating data with information; "ready consumption" constitutes the salient distinction. People consume information as they find it, while they have to translate data into information to consume it. We mis-categorize this with the term "raw data" versus "useable data," but regardless of the adjective, data must be analyzed and translated to create information.

In our quest for "actionable" intelligence we have increased our ISR collection to the point of uselessness. Air Force Intelligence Agency operates in 65 locations worldwide, One might surmise that the United States flies ISR missions in most of the 150 countries in which the US military has missions. After adding the amount of data our space-based assets produce, you can quickly understand how much data we generate. At best we can claim that we are archiving data for analysis later. At worst we must realize that we do not have a reason to collect the clear majority of data. The intelligence community has discussed this problem and analyzed it since the proliferation of RPA technology and persistent ISR. The intelligence community considers using big data computing to solve this problem, but this still does not turn real-time data into information we can use.

It is beyond obvious to state that we depend on information at all levels to plan and conduct military operations, yet our insatiable appetite for ISR has created a data regime that provides more data than we can use. The sad fact, however, is we collect far more data than we can ever hope to analyze, and while we acknowledge this, we have not made any meaningful progress in turning this vast amount of data from our ISR into any usable information. In fact, we turn to promised solutions through greater computing power and algorithms. While super computers and algorithms will assist us in this endeavor, we must understand that until an artificial intelligence is developed that is capable of inductive reasoning, humans remain the best

source of synthesizing data into usable information. The main problem with this, paradoxically, is not our ability to process vast amounts of data, we do this every day, but how we present information to our brains. In order to process data into information we must, first, translate that data into a consumable form before it can analyze and act on it. I propose a radical departure in design and heuristics by requiring technology to present information in ways that humans natively process information. I call this "Human Native Form".

VII. The Human Brain and Human Native Form:

Since we created computers we have, as a species, drawn analogies between the human brain and a computer. This is a false analogy and has limited our development of accurate models of cognition and, consequently, retarded our understanding of how we would *prefer* to interact with machines and computers. As discussed in the third section of this paper, our early attempts at interfacing with machines was a machine centric approach. This is a trend for humans, we identify with our creations to the point we cater to them. In the same way, our early interactions with computers and data were very computer and data centric rather than human centric. Since the internet's creation gave access to the world's vast cache of data we begun looking more at the utility of information. For example, a farmer's field has not changed since the first crops were grown by humans. The micro climates and nutrient requirements have existed since time immemorial; we simply had no way to understand this, and when we did we had no way to gather the data efficiently. Now the problem is how to best use that data. In the same vein, HNF seeks to allow us to tap into the vast amounts of data available and present it as useable information that humans can natively process through our senses.

For example, a cellular phone set to vibrate when you receive a phone call translates the information (someone is calling you) into HNF by making that alert a somatosensory, or tactile, sensation. The closest idea approaching the theory HNF is the study of Human Factors or

Ergonomics. The main difference is that Human Factors and Ergonomics deal mainly with physical interaction between humans and "things". Ergonomics is a useful way to make physical things work better with humans, and in the same way HNF seeks to accomplish the same thing with information and not necessarily physical things. As in our example of the cellular phone on vibrate the information (someone is calling) is translated to a sensation that allows our mind to process the tactile sensation of vibration as information. This provides the information while decreasing cognitive load required to monitor the status of the phone.

As our understanding of how the brain works increases our mastery of HNF should, likewise increase. It is, therefore, useful to walk through a very simplified example of how our brain gathers, stores, and processes data into information and how this influences HNF.

Information processing starts with sensory input from our sensory organs. Our senses translate physical stimuli (heat/cold, touch, reflected light, vibrations/sound, etc…) into electrochemical signals. Once gathered this data is processed by our brains in either bottom-up or top-down processing. Bottom-up processing requires you to characterize a new thing from sensory input. For example, the first time a baby tastes a lemon it has to create an impression from scratch. Top-down processing uses what we have previously created through bottom-up processing to speed up processing.[28] The second time the baby sees a lemon they might not taste it so willingly, depending on their initial assessment of its sour taste!

There is no shortage of stimuli for our brain to process, and this could quickly overwhelm our cognitive ability. To combat this our brain employs attention filters.[29] These filters help us decide what is important to commit processing power to. When we look at trees we do not notice each individual leaf (unless that is our goal in looking at the tree), rather we apply an attention filter and merely characterize the tree as a whole rather than its constituent parts. Attention filters are useful to alert us to stimuli we want to be alerted by. A parent can usually pick their child's

voice out even in the noisiest lunchroom. HNF augments these attention filters by allowing your natural attention filters to prioritize what information you want presented.

Once you gather the data (stimulus) and apply the correct cognitive process to it your brain must decide what to do with the processed information—do you retain it in long term memory or allow it to be forgotten from your working memory? Studies indicate that our working memory stores "information for roughly 20 seconds […] by an electrical looping through a particular series of neurons for a short period of time." [30] This information might be stored or later recalled. If so the electrical signal is put into long term memory. Scientists hypothesize long term memories are "maintained in the structure of certain types of proteins" that are destroyed and rebuilt each time the memory is accessed.[31] This destructive and reconstructive accessing of memories can use large portions of the brain. In 2016 Brian Levine of the University of Toronto conducted a study on memory recall with plane crash survivors and found an increase in neural activity in "the amygdala, medial temporal lobe, anterior and posterior midline, and visual cortex of the passengers."[32] Memory recall is cognitively intensive while recognition is not. Humans are hardwired to use cognitive shortcuts, like top-down processing, to free up working memory and processing power. Rather than having to recall information we can simply recognize it, which is much less cognitively taxing. Recalling something requires us to relive the experience and involves many parts of the brain. Recognizing something only requires us to tap into a previous experience that has already changed our brain previously.

According to Dr. Robert Epstein, a senior research psychologist at the American Institute for Behavioral Research and Technology in California, the brain is changed by each activity and stimulus. This is what makes humans more effective at recognizing than recall.

> As we navigate through the world, we are changed by a variety of experiences. Of special note are experiences of three types: (1) we observe what is happening around us (other people behaving, sounds of music, instructions directed at us, words on pages, images on

screens); (2) we are exposed to the pairing of unimportant stimuli (such as sirens) with important stimuli (such as the appearance of police cars); (3) we are punished or rewarded for behaving in certain ways. We become more effective in our lives if we change in ways that are consistent with these experiences.[33]

Recognizing when to change is vital in this equation, and to do know when to do so requires us to interact with our environment while we are experiencing it and, at times, changing it. In his book, *Radical Embodied Cognitive Science,* Professor Anthony Chemero describes intelligent behavior as "direct interaction between organisms and their world."[34] Human native form allows us to directly interact with our world while accessing information we would not have without augmenting our senses by presenting processed data as stimuli we natively process and understand.

VIII. Conclusion:

As we travel further into the information age and our understanding of how humans think we must be very deliberate in how we choose to engage with technology. We are at the point in human history where technology is advanced enough to enable us to more effectively focus on human ways of acting rather than the technology. Simply put, we must make technology adapt to us. To accomplish this, we simply must focus on what makes a human a human and create ways that take advantage of this. There is a reason that Homo sapiens are the dominant species. Our natural abilities are many and tailor-made to dominate our environment. Now that we have created an artificial environment full of data we must create ways to harness that data for our benefit the same as we do any other data we receive as natural stimuli. Human Native Form serves as a unifying principle for that purpose.

IX: SOF Operations, 2058 A.D.

Max was pensive today, and not sure why. The drive to base was pleasant enough. The autonomous car drove through the tall pine forests of North Carolina while Max read through the

news feeds and enjoyed his morning coffee. Gastronomists would think this morning ritual old

fashioned as they ingested caffeine in pill form along with their individually tailored vitamin and

mineral pills. Even so, Max thought, I still enjoy my coffee. Perhaps it was because it reminded

him of weekends as a kid when his father would let him have a cup of "coffee" which was more

milk and sugar than coffee. Maybe it was the same reason he used an old mug and brush to apply

shaving cream when he shaved. Sometimes the old ways were better. Sometimes they were

not… The nanobots in his body that augmented his natural immune system were definitely better

than the old antibiotics and vaccines. Those little guys flowed through the body on a constant

patrol for any number of problems. They kept his heart healthy, even though he was genetically

predisposed to heart disease, by removing any plaques before they could cause a problem. They

also were the reason death from cancer was almost unheard of—they could physically remove the

rogue cells before they could metastasize.[35]

Max walked into the building an hour before the briefing to complete a few last minute

mission planning details. As he walked down the hallway to the armory, he put on the slim

eyeglasses-like visor of his SOF HUD and began looking at the environmental feed to check

terrestrial and space weather. He wanted to see if the recent solar flares would interfere with the

communication relay satellites. If so the team would rely on an *ad hoc* network formed by their

individual computers and radios. If they could communicate though the satellites to the data

farms and quantum computers in the continental United States (CONUS) the team would have

access to nearly unlimited information, making their mission much easier. Data was pulled from

the cloud, processed into useable data, and presented as information in the form of a natural

human sense. It took only a second to get used to receiving information as either haptic feedback,

3d audio, or visually because that is how humans are wired to receive information. Like every bit

of simple common sense presented in an academic paper at one time this obdurate fact had a

name: Human Native Form (HNF). Simply put, HNF allowed the user to bypass processing data

and simply receive information. Max remembered his dad telling him about the TALOS "Iron

Man Suit" the old special operations command tried to build in the early 2010s. The problem

with the suit was that the person inside of it was completely removed from the environment and

was unable to function as a human should. It was somewhat comical to see the old test footage of

an operator trying to climb stairs in the suit. They had no spatial awareness because they were

cocooned into a metal exoskeleton. Worse was the fact that the early suits broke the wearer's

arms because the suit was not able to limit the movement of the elbow joint to accommodate the

user.[36] HNF suggested a different approach: stop isolating the human with "augments to their

ability" and integrate them. In the case of the TALOS a haptic suit with bio feedback tied into

the suit fixed the problem. With the suit on under the TALOS the user was able to "feel" the

ground underfoot and climb stairs easily, and the bio feedback allowed the suit to automatically

limit its range of motion to the individual user.

The weather information floated a few feet from his eyes as holographic images allowed

him to intuit the information he wanted. The solar flares necessitated a few of the satellites to re-

position which degraded the coverage of his op area. This might interrupt his transmissions to the

satellites that would relay battle information back to the command and control center at Ft. Bragg,

NC. Not a problem; he would simply let his team know they should expect their drone-borne

network to be primary. This meant that they might not be able to tap into the massive computing

power of the homeland and would, instead, rely on the smaller AI network diffused among the

squad's built in suit-processers and whatever systems the drones carried. That was not as big a

problem as it once was.

When the US began relying on its information systems to conduct operations it gave them

an asymmetric advantage. Operation Desert Storm was called the first space war because GPS

and precision guided weapons allowed US forces to quickly and decisively defeat the Iraqi forces.

The once trackless desert of Arabia was now an open highway for American armor because GPS

meant they were never lost and could move anywhere while the Iraqi army relied on roadways.

Precision guided weapons dropped by early stealth aircraft destroyed the Iraqi Command and

Control networks paralyzing their forces. Meanwhile, American forces were able to use precision

timing to synchronize their efforts in ways unheard of before that conflict. The success of Desert

Storm was a lesson the world learned from. The US began beefing up its ability to exploit

networked warfare while the rest of the world figured out how to defeat it.

Asymmetry answered in the form of terrorism, and made many of the advantages the US

relied on liabilities. Networked warfare enabled drone strikes but also isolated the US from the

populations the terrorists were living among. While the US was able to nearly strike any terrorist

at will they became the faceless bringers of death and alienated much of the population where

they were striking. China and Russia exploited this ill feeling and moved into the alienated areas.

China offered assistance to the people, and established "Stadium Diplomacy".[37] Rather than

focusing on infrastructure and improvements like clean water sources, China built elaborate

soccer stadiums in Latin America and Africa. This gained them popularity and access to these

areas and allowed them to ship raw materials home to China. In a strange twist of irony the

poorest regions of the world seemed to hold the most important elements. Rare earth elements in

Africa were mined by Chinese companies who gained mining concessions due to goodwill gained

by stadium diplomacy and kickbacks to government officials, and shipped back to China to be

made into high-tech items. China's rise in the early part of the 21st century was a direct result of

this process. Rampant espionage allowed China to modernize its military equipment and

challenge the US asymmetric technological advantage. Terrorists defeated US technology with

low tech tactics while China closed the technological gap and edged past the US with a

successful, if corrupt, foreign policy. It was a relief to think at the tactical level, rather than the underlying international relations, Max thought. Competition between the US and China kept the two countries one or two conflicts from war for years. In 2030 China tried to coerce the US by cutting off supplies of microchips. It was only US private industry's earlier investments in micro-3d printing and commercial space flight that kept the US from suffering more.

When funding for NASA was slashed in the early 2000's it looked like the US was abdicating its leading role in the space domain. The war on terror was sucking too much of the budget to justify the "Buck Rodgers" research. People scoffed at asteroid mining, except a few eccentric billionaires that is.[38] Eccentricities started to look like profitable vision once the first mining bots landed on an asteroid. It turned out elements that are rare on Earth are fairly plentiful in space… When they sent their cargo of once rare elements back to earth no one doubted, and the space gold rush started in earnest. Most of the equipment Max relied on was made with resources mined in space and printed by US companies.

Max pulled up the current intelligence for today's mission. It should be low threat. They would insert a few miles from the objective and walk in to the target area. They and the target would be watched by the unblinking eye of the intelligence, surveillance and reconnaissance enterprise. This data would be processed, relayed through the network and then populate his team's SOF HUDs with a constant stream of real-time information. Biofeedback sensors would monitor cognitive load and tailor the amount of information presented. This ensured that only what was required and able to be processed was presented. Of course they could call up any information as required. Cogitative load mapping algorithms took thousands of readings every second and fed these through the HNF algorithms to keep each operator at their optimal level of cognitive stimulation.

As he entered the armory, Max pulled up the target's pattern of life (PoL) info from the last several days. The target building had been identified and the target's movements were plotted at tracks giving Max a picture of his daily habits. The algorithm suggested the best time to capture the target was right at dusk. The proliferation of night vision meant the advantage the US initially enjoyed fighting at night was negated, but multispectral imaging goggles and off-board sensors feeding the SOF HUD gave a decided advantage regardless. Light conditions at dusk negated any advantage of night vison as well.

From the readout on his SOF HUD it looked like the targeting algorithms picked dusk to strike to limit the chance of collateral damage and the target would most likely be sitting on the couch in a room with an exterior wall. As good as this intelligence most likely was (the AI declared it a 92% certainty the target would be on the couch watching TV) Max knew he would rely on the near-predictive tracks computed from the vast amount of ISR collected once on target. Near predictive tracks were so accurate because the target was under surveillance for so long that a huge data set of the area was compiled and broken down into algorithmic patterns of actions. The complex movements of the crowded slum was distilled into useable information—while near predictive could not read minds or see into the future, it sometimes felt like it. Near-predictive tracks were presented as holographic lines on his SOF HUD. The cameras in his and his squad's SOF HUDs would network with the ISR feeds and then be fed into a computer and come up with the most likely actions someone could take. This had proved useful a few times on other missions.

During another mission Max remembered being surprised by a new weapon placement. As he was approaching the objective rally point on the way to a target, he was surprised by a tell-tale sound of machine gun fire passing nearby from a hidden source. The acoustic sensors on his battle suit triangulated the origin of the shot and indicated it in his SOF HUD with a flashing red

triangle. Max's vision filled with shaded green areas where he could take cover. Once he was safely behind a burnt out truck, his computer's artificial intelligence (AI) sorted through terabytes of data produced by the network in real-time and suggested a course of action (COA): stay put while it called in a portion of a nearby drone swarm to return and destroy the machine gun. As the three micro drones raced in to destroy the threat, the AI network uploaded the new position, looked through all of the ISR feeds, identified who placed the automated gun trap and updated the algorithm to account for a new enemy tactic. It also added the man who set the trap's biometrics into the intelligence database. This all happened in a split second.

Later during the same mission, the AI predicted that the terrorist operative would try and escape rather than fight. Max ordered his squad to block all possible escape routes before they breached the target building. Sure enough, the terrorist ran right into one of the blocking positions and was safely captured. While near predictive were impressive they were not new technology (or algorithms more accurately), but were simply a small leap from theories developed decades ago for agriculture and in the quest for autonomous cars. [39]

In the early part of the twenty first century farmers were having trouble with pollinating crops.[40] Indiscriminate use of pesticides and insecticides decimated bee populations and effected pollination and crop production. When outlawing chemicals killing the bees did not result in a rebound of the population scientists turned to chaos and game theories to model and solve the problem. These models indicated that ecosystems were largely destroyed—displaced bees cannot live very long… The solution was simple: make micro ecosystems for bees, but computing the solution was anything but simple. Bees form complex systems by themselves, but add human behavior and environmental change into that and you face a wickedly complex system. Thanks to tremendous computing power analyzing vast amounts of data the wicked complex problem was analyzed and deciphered with game theory, artificial intelligence (AI) and machine learning.

Max was always amazed that software initially developed for beekeepers, crossed with a program that runs a city's autonomous car network opened the study of near-predictive tracks. This breakthrough helped scientists understand how thousands of starlings could fly so coherently without sharing a consciousness. Every fleet of small drones had this logic hardwired into it making autonomous drone swarms possible.[41] These swarms were truly a networked entity. Back in the distant dark ages when Max's father was still flying, and the DoD thought it was networked. Perhaps they were with communications, but they were only beginning to understand the implications and uses of networking outside of communications (be it digital or voice). They had not yet grasped the power that came from networking humans and machines with AI and machine learning. Of course, before Human Native Form theory described how technology and humans should interact, we could not fully grasp what to do with all of the data we were generating. In fact, his generation of warriors never fully used the data they generated, it was only in the last decades that the billions of terabytes of data that were generated during the War on Terror was fed into the modern computing system for analysis. The insights gleaned from this this study helped produce doctrine and strategy still used today. It is strange to think of collecting so much *data* without the ability to *use* it. The only thing that made such expensive and time consuming efforts worthwhile was its utility as a historical case study to plug into the machines to learn from. Decades of patterns of life, operations and results were fed into the computers and digested. The machine learning created new algorithms and new insights that, ultimately, became the doctrine, tactics, techniques and procedures (TTPs) that transformed our conception of how to use technology.

In 2014 Secretary of Defense, Chuck Hagel, announced the Defense Innovation Initiative to create a "game changing third offset".[42] His short speech sparked a revolution in innovative thought; the intellectual shackles were off and crazy ideas were encouraged. Who would have

thought that an Air Force Officer at Air Command and Staff College could develop a theory that would unify man and machine? That swarm technology would start on a napkin at the officers club in the middle of the Llano Estacado at Cannon AFB? Airmen have always been full of ideas, but few were given the opportunity to explore them before Secretary Hagel's announcement. What kept this new focus from being another management buzzword was a new freedom to explore ideas and new partnerships between industry and the military. These relationships created collisions of people and ideas that sparked most of the technological innovations that kept the United States first among the nations on earth. The spark provided by Secretary Hagel and other visionaries took advantage of America's greatest asset—the intellectual capital of its sons and daughters. All of the history crammed into Max's head by his father flickered in his mind, tracing an ever upwards trajectory of American power that was paralleled with its intellectual growth and freedom of thought. American innovation spurred industrialization, improvements in agriculture, space travel, computers and the internet that still benefited the entire world. These advances were created by innovation generated by American minds and made into reality by hard work and industrial capacity.

During World War II, the United States created an industrial machine unequaled in -human history—by the war's end US production accounted for half of the world's industrial output. In 1941, alone, the US launched more ships than Japan built the entire war, the Ford motor company produced a new vehicle every 63 seconds, and by war's end the US produced 297,000 aircraft, 193,000 artillery pieces, 86,000 tanks and two million army trucks.[43] While industrial capacity was one of the decisive factors in WWII it was innovation that kept the US ahead in the century after WWII.

When the Cold War began the race for space kicked off. President Kennedy called for the US to land a man on the moon within the decade—the US did not have a credible space program

when the challenge was voiced! Yet, within the decade the American Flag was planted on the

moon. Unfortunately for Max's family when they visited the moon a few years back the first

landing site was a disappointment. The original flag was still on its staff but had been bleached

white by solar radiation. While it took Apollo 11 75 hours and 56 minutes to reach lunar orbit, it

only took Max's family a mere three hours and that was in the comfort of a leather upholstered

seat with drink service and snacks. The same technology that allows tours of the moon and

asteroid mining also lets his team launch from the American homeland and strike targets across

the world without the need of forward basing.

This became necessary once China's anti-access/ area denial (A2AD) effectively blocked

any navy or air force from approaching their shores without serious threat. It became untenable

to plan on sitting a carrier off their shore and projecting power from the sea. The unquestioned

access that enabled Max's father to fight anywhere on the world was a thing of the past. Today

you had to fight to get to the fight.[44] When Marine Corps Commandant General Robert Neller

said this in 2017 many thought it was hyperbole, but as China built up the first island chain and

put in defenses capable of knocking out carriers, it was obvious that to move a ship though the

South China Sea was suicide unless the Chines wanted you to be there. Max remembered

watching China become the reginal hegemon of the South China and rolling over Vietnam in a

series of small scale operations in the South China Sea as a high school student.

Thanks to the hindsight of history, China's domination of the South China Sea seemed

inevitable—it first fought Vietnam over the Parcel Islands in 1974 and again in 1988 over the

Spratley Islands.[45] China flexed its naval strength and occupied the islands while pushing its

claims on resources out to what used to be the international commons. It continued to do so until

it occupied most of the rocky islands. They built these islands up and added denial weapons to

them to the point where they now control access to the world's most busy sea lanes. Because of

A2AD the US was forced to rethink its forward presence. Power projection was still necessary but too risky to do so from all of the forward bases. New technology was needed to enable power projection from the homeland. The second space revolution in the decades from 2010-2030 saw the development of reusable rockets and hypersonic planes that could launch from a terrestrial runway, skip across the earth's atmosphere like a stone across the lake and travel across the globe in a matter of minutes. It also made asteroid mining and space tourism possible. For his 80th birthday Max and his brother, Carson, bought their father a ticket to visit the moon. As boys they remembered their father telling them that he used every one of his birthday wishes on being an astronaut. He spent his career in the Air Force but never got to go to space. He remembered the tears in the old man's eyes as he opened the envelope. "How the world has shrunk and man has grown", the old man remarked, as he used his sleeve to wipe the tears away.

Max shook his head and reflected that while the nature of war was still very much a human endeavor, its character had changed since his grandfather was forced to bail out over North Vietnam after his F-105 was hit with an SA-2 surface to air missile the size of an old telephone pole. Even the description of the missile was old fashioned. It was difficult to remember his childhood where power and communications were transmitted along copper wires strung between pine trees stuck into the ground at even intervals. It was even more difficult to think about his his how his father would mission plan. His study was still littered with old air charts and he still insisted on using his old metal dividers to calculate distance while speed and endurance was computed with the MB-4. Max chuckled to himself when he remembered playing with the ancient circular slide rule that had "MB-4 Dead Reckoning Computer" etched into its aluminum frame below tiny tick marks and numbers. "Computer" indeed. It bore little resemblance to the ubiquitous tiny processers of today. Humanity learned to offload much of the processing to small computers while retaining processes and tasks intrinsically human. Things

that the limbic system does well—the decisions made by "gut feeling" have not yet been

replicated by computers. Scientists are still more interested in how a human beat a computer

once in a game of Go than they are by the expected defeat of the human by a powerful computer

called AlphaGo. AlphaGo lost even though it was using neural networks, running thousands of

algorithms in real-time, but technologists and the public overlooked this fact for years.[46] Early on

the news was full of stories touting the fact that AlphaGo beat a human master. In 2015 when

AlphaGo beat the South Korean Go master, Lee Sedol, humanism still held primacy in popular

thought. An image of a visiting lecturer, Dr, Yuval Noah Harari, discussing how humanism

shaped western beliefs from the Scientific Revolution to the dawn of the Information Age came

to Max's mind.

> During the Agricultural Revolution humankind silenced animals and plants, and turned the animist grand opera into a dialogue between man and gods. During the Scientific Revolution humankind silenced the gods too. The world was now a one-man show. Humankind stood alone on an empty stage, talking to itself, negotiating with no one and acquiring enormous powers without any obligations. Having deciphered the mute laws of physics, chemistry and biology, humankind now does with them as it pleases. […] The Scientific Revolution gave birth to humanist religions, in which humans replaced gods. […] The founding ideas of humanist religions like liberalism, communism and Nazism is that *Homo Sapiens* has some unique and sacred essence that is the source of all meaning and authority in the universe.[47]

It was no wonder that people were initially shocked that a computer, a mere *machine*, could out

think the wonderfully complex human brain *four out of five games*! Descartes famously distilled

humanity to thought, "I think therefore I am," people scrambled to answer, "could computers

think?" and if so does this make them alive in the same way humans are? Most people were

comforted by thinking that true intelligence had to be organic, and computers were simply

applying algorithms and logic rather than using true intelligence. This held true as militaries and

science attempted to replace humans on the battlefield with completely autonomous weapon

systems. Testing quickly showed that humans were much more devious than their robotic

opponent, even with all the limitations that come with being human. Much like Odysseus out smarted the gods in the Odyssey, humans were able to out fox robotic warriors by intuiting solutions.[48] Thus, it became obvious that machines would not necessarily replace humans, rather they would take on tasks that they could do well while humans continued focusing on being human. Artificial intelligence did well translating data into information but lagged behind humans in making *decisions*. Is seems that even with big data feeding super computers counter-intuitive thinking and decisions were still within the sole dominion of *Homo Sapiens*. That being said there were advances being made into synthesized intelligence which looked at replicating the ability of an organic brain in a computer. A recent article on Max's news feed tried to explain the concept.

Max pondered the difference, it sounded like a semantic argument rather than a true distinction, but the author of the article made a convincing case. He posited that synthetic intelligence was different because it was developed in a "bottom-up way from systems of molecular and cellular elements, designed and fabricated from the molecular level and up." He taught that the emphasis on the replication of mere cognitive operations based on simple logic was wrong and synthetic intelligence relied on designing self-replicating, self-assembling and self-organizing systems would generate cognizing systems that would be analogous to the human neurobiological cognition.[49] When programmers and biologists joined their disciplines together they created such a system but it was not yet in use outside of university labs. Which, as far as his dad's generation was concerned was just fine. They grew up watching too many science fiction movies about robots and computers taking over the world to be really comfortable with a truly thinking computer.

As he approached his equipment stand his SOF HUD scanned his augmented exo skeleton's diagnostic report. The left leg had a small fracture in its armor and a few broken fiber

optic relays. A young technician approached him, "Sir, you noticed the damaged part of the suit? Don't worry we are just about finished printing you a new part, it will be completed by the time you complete your brief."

"Thanks, can you make sure it is reinforced on the shin? This is the second leg that has cracked in the same area."

"Yes sir. The suit's diagnostics has accounted for that and made the modification to the part. It determined that you are developing a small limp as a result of an injury to your right hip which is causing you to favor your left leg. Would you like me to perform a scan of your gait to pinpoint the cause?"

"No thanks, I'll stop by the auto-doc later and get the full report." At 50, Max looked much younger than his years would indicate, but even with the amazing advances in medicine he was developing the aches and pains of age. That being said, back in his father's day, it was unusual for Special Forces to be in the field at the age of 35. The combination of physical and mental training led to vast improvements in operator health. Back in 2009 US Army Special Operations Command (USASOC) began hiring NFL strength coaches and physiologists. They developed a program they called Tactical Human Optimization, Rapid Rehabilitation and Reconditioning or THOR[3]. THOR[3] was a "holistic approach to improving physical and mental performance, its focus on individual and unit needs, and its reliance on a professional staff of program coordinators, strength and conditioning coaches, physical therapists, dietitians, and cognitive enhancement specialists to deliver training and rehabilitation services that are on par with those provided to professional sports teams." Individualized development plans were created—nutritionists developed individualized diets for each soldier, strength coaches created individual workout programs and physiologists produced cognitive training for each person. The result was a 20 percent increase in physical and mental resiliency of Special Forces soldiers.[50,51]

Max's personal fitness level rapidly increased during his time as a cadet at the Joint Defense Service Academy 30 years ago. The fact that he beat his cadet physical fitness performance during this year's test was a testament to the effectiveness of the program. This program trickled down to the civilian population as well. The average citizen in 2058 could expect to enjoy good health and a longer life than their parents. In the last fifty years the average life expectancy for citizens of developed nations averaged around 110 years. At 50, Max was just entering middle age.

Max put on his haptic under-suit that tied his senses into the exo-skeleton. It fit snugly; the compression made his muscles more efficient. The haptic suit was woven with microscopic filaments that kept his body's temperature regulated. As soon as the suit was on a brief vibration indicated the kinetic servos were providing power to the suit. Max then stepped into the exo-skeleton and felt it click into place. He was suited up. The SOF HUD showed all systems green. Max walked across the hall and stepped into a large hanger where he would board the hypersonic transport. His squad was already onboard and strapped into their stations.

As Max walked up the ramp on to the sleek ship the crew chief snapped a smart salute, "Good luck, Sir!"

"Thanks, see you in a few hours."\

Once on board, Max strapped into his pod for the ride. He called for the pod's computer to bring up the briefing interface. A holographic image of his squad popped up. They were all reporting systems green. Rather than talking to the squad Max simply uploaded his proposed scheme of maneuver. Since the squad members were robotic there was no question that they were ready.

Appendix A: SOF HUD Hackathon After Action Report

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

25 Jan 18

MEMORANDUM FOR RECORD
FROM: C. CHRISTIAN LOWRY
SUBJECT: SOF HUD Hackathon After Action Report: 14-17 December 2017

1. Background:

    a. On 14-17 Dec 17, Major C. Christian Lowry conducted a Hackathon in Montgomery Alabama to create a prototype Special Operations Forces Heads-Up Display (SOF HUD) using Augmented Reality (AR) with commercial off the shelf (COTS) technology and hackathon participants. The hackathon was hosted in a local collaborative work space, COWERX46, and sponsored by the City of Montgomery and the Montgomery Area Chamber of Commerce at no cost to the USAF.

    b. During the three-day event, 23 participants from around the US came to downtown Montgomery and programmed an initial prototype SOF HUD using DAQRI's Smart Glasses (Technical specifications for the glasses are included in Appendix B) and the Unity programing language. Several Subject Matter Experts (SMEs) attended for the initial kickoff event and several technological experts (from DAQRI) were connected and on call via distributed operations (i.e. VTC, message boards and online collaborative work tools. Capt Brad Henicke's trip report is presented in Appendix C.

2. Discussion:

    A. SOF HUD: The SOF HUD idea capitalizes on the theory of Human Native Form by using visual cues to provide information that would be otherwise unavailable.
        1. HNF theory posits that humans perceive the environment through senses and processes the sense *natively* producing useable information. This bypasses the need to translate data into information through cognition. HNF presents information instead of data, which decreases cognitive load and increases available working memory while providing more information to the user; thus, allowing better informed decisions and faster more decisive actions.
        2. SOF HUD presents networked off-board information to the user visually using AR, allowing users to overlay information onto the real world (see Capt Henicke's Trip Report for his summary of the event as well as photographs taken through the AR device in Appendix C). This approach makes heretofore information available by translating vast amounts of data available before it hits the working memory. This can be tailored to any number of missions and environments ranging from ground and aerial combat to maintenance or even medical applications and only depends on what information is usable and what data is available. HNF lends itself to any application where vast amounts of data need to be synthesized into information quickly in order for it to be acted on.

3. The DAQRI Smart glasses were the platform for prototype design, but SOF HUD is device agnostic. Technology is moving very quickly, and this is especially true in the field of AR. The purpose of this prototype is to showcase the idea and utility of HNF on the battlefield and create a rapid prototype at a low cost. The hackathon created a SOF HUD demonstrator prototype and validated HNF. **It is strongly recommended that resources be allocated to bring SOF HUD online and explore how to exploit HNF for battle.**

B. Hackathon Structure and Execution:

1. Building a Team from Local Experts: Due to budget constraints and my lack of programming ability, I choose to recruit expert help in creating the SOF HUD prototype. I sought the advice of Mr. Boyd Stephens, an IT professional and entrepreneur. Mr. Stephens suggested that we seek the help of local programming clubs, such as Code America and HackMGM as well as area colleges. HackMGM has held several hackathons in conjunction with other events in town with some success; however, the previous events were limited in scope and were competitions between individuals or teams with a preconceived solution to various technological problems.

2. Steering Committee: Mr. Stephens linked me with Mr. Bryant Noel who is former USAF SSgt and IT professional. Mr. Noel took on the role of technological project manager and event facilitator. Additionally, Ms. Charisse Stokes joined the team and facilitated the Hackathon event and recruitment. She is a former USAF officer and heavily involved with the Armed Forces Communications and Electronics Association (AFCEA) and its education foundation. This team was the core group that planned the hackathon and was vital to this successful event and process. They were volunteers who put a great deal of effort and expertise into the event.

3. Civ-Mil Partnership: I worked with the Mayor of Montgomery and the President of the Chamber of Commerce to sponsor the event. Under Mayor Todd Strange's leadership, Montgomery is focusing on becoming a regional center of innovation. Most recently, Montgomery acquired an internet exchange and is home to more IT professionals per capita than any other city in the Southeast outside of Atlanta.

   a. The Mayor and the Chamber of Commerce supported the hackathon to further the creation of an ecosystem that engenders innovation and economic growth. City and community leaders recognize the utility of encouraging and supporting these type of events in the city to recruit and retain talent. The SOF HUD hackathon coincided with Lt Gen Kwast's announcement that AETC and Air University are partnering with the City of Montgomery to create an innovation center in downtown Montgomery. The successful completion of the SOF HUD hackathon was touted as validation and proof an innovation ecosystem was growing outside of Maxwell AFB in Montgomery.

   b. The Chamber of Commerce offered to sponsor the event. They paid for Ms. Stephanie Wander, a professor at the University of Southern California and senior prize developer for X Prize to attend the event and give a keynote speech. The Chamber also provided press releases, media production, gift-bags for the participants, and food for the event.

      c. DAQRI also provided promotional items for the participants.

4. Participants: Participant experience with the Unity programing language varied from none to some limited past experience with an earlier version of the language. Because the DAQRI Smart Glasses are new technology, no participant had any prior experience or familiarity with the hardware. Participants included professional programmers, active-duty airmen and high school students.

      a. Recruiting Participants: Participants were recruited from local clubs Universities and High Schools, military, and industry. They were contacted through a variety of methods including: direct contact, electronic mailers, social media, and targeted invitations. The registration window was one and a half weeks prior to the event and 23 developers registered. In future events, a longer recruitment period and wider marketing should be considered to net a larger and more diverse group of participants. However, this was the best attended Hackathon to date in Montgomery and the first hosted by Air University.

         1. Ms. Stokes and Mr. Stephens were able to recruit programmers from local educational institutes and Gunter Annex, Maxwell AFB. My recruitment efforts focused on industry and military organizations. To illustrate, an Atlanta-based company, Datum Software, sponsored two of its programmers to travel from Warner Robbins, GA to participate. AFRL sent a participant from the Gaming Research and Integration Learning Laboratory (GRILL). Because of GRILL's involvement, we were able to tie into their expert programmers to assist the participants using distributed operations. I also attended several HackMGM events to recruit talent, and used social media to publicize the event by piggybacking on DAQRI and other AR blogs.

         2. I reached out to the Air Force's Defense Technology Accelerator to link the SOF HUD's development with an existent Air Force program. The Technology Accelerator began as an SOS Think Tank project in which I was involved. This avenue should prove important in gaining large-scale recognition of important projects and will prove incredibly important to the USAF.

5. Physical Space and Equipment:

      a. The event was held in a local co-working space in downtown Montgomery. CoWerx46 is located at 46 Commerce Street Montgomery and is within walking distance to three hotels, numerous restaurants and other entertainment venues. It is also in the heart of the downtown business district and entertainment district. This part of downtown is experiencing a renaissance and is one of the more eclectic and vibrant areas of Montgomery. This environment makes it easier to attract people to events like this hackathon.

      b. The building has open collaborative space, a conference room and high speed wireless internet with plenty of white board space and tables. The participants rated the space as adequate with the chief complaint being a lack of a coffee pot. We opened the workspace at 0800 each morning of the event and closed it when the last participant left, which usually occurred 2330.

    c. Lodging: Participants were responsible for their own lodging; however the Chamber of Commerce arraigned reduced hotel prices for participants. Future events would benefit from lodging being provided to participants. For example, several participants stated they would love to be able to have berthing quarters attached to the workspace. Participants also maintained more out of town talent would participate and events could be longer if lodging was provided.

    d. Hardware/Event Materials: Several participants arrived without computers or inadequate computers. Mr. Stephens provided several powerful workstations for the event. Future events would greatly benefit from workstations being available in addition to power outlets and internet connections for personal computers spaced around the work space.

    e. The USAF moved funds from AETC to SOCOM Det 1 to purchase DAQRI Smart Glasses at a cost of $14,985 for three units ($4,995 each). The decision to use DAQRI's hardware was based on the capabilities of the system. While I researched the other AR systems available at the time, I concluded that the DAQRI system best fit the design needs of developing the initial prototype because it was able to interface with android devices that are currently used by SOF in combat. The hardware was adequate for this event, but suffered from a lack of integrated GPS.

    f. SOCOM Det 1 also provided three Samsung Galaxy S7s. These are the units that SOF carries into battle to use the Advanced Team Awareness Kit (ATAK) which runs several android-based apps for use on the battlefield. These apps range from mapping apps to tactical notebooks.

6. Schedule of Events:
    a. Thurs, Dec 14th : Event Kickoff
    5:30PM - 8:30PM: Intro/User Brief and Sprint Planning
    b. Fri, Dec 15th: Project Day
    8:00AM - 6:00PM: Prototype Development
    c. Sat, Dec 16th: Project Day
    8:00AM - 6:00PM: Prototype Development
    d. Sun, Dec 17th: Demo Day
    10:30AM - 1:00PM: Demonstrations, Peer Evaluations and Outbrief

7. Execution:
    a. Open to the public, the kickoff event generated wide interest and was well attended. It showcased a new method to accelerate technology development it was well attended by state and city government officials, industry and military leaders. The Mayor of Montgomery provided the opening remarks and then Major Lowry framed the problem.

      1. Major Lowry outlined HNF and how SOF HUD should exploit the theory by presenting information to the user.

      2. Several SMEs gave their "user stories" to frame the problem and give the participants a description of what would be useful in a SOF HUD. The SMEs were: Major Rich Harr, U-28 Weapons Instructor, Major Charles Hodges, a Special Tactics Officer, and Capt Brad Henicke, U-28 Pilot).

      3. Mr. Noel helped the team organize along the principles of sprint

planning and took the role of Scrum Master.

    a. Sprint planning is a collaborative effort. Several roles facilitate the method: a Scrum Master facilitates meetings and process, the Product Owner clarifies product details and acceptance criteria. The participants make up the Agile Team. They define what work and effort are necessary to meet their sprint commitment. (https://www.leadingagile.com/2012/08/simple-cheat-sheet-to-sprint-planning-meeting/ accessed 12 Jan 18)

    b. The group focused on presenting three key items on the SOF HUD for the hackathon:

      i. Present position of self in Military Grid Reference System (MGRS)

      ii. Range and bearing to a user-specified target and other users

      iii. Moving map showing all other users, targets and present position as icons

4. Once the teams were organized by ability and interest, they began working on their assigned sections.

5. On Friday, 15 Dec 17, Stephanie Wander (Senior Prize Developer, X-Prize and Professor, University of Southern California) gave the keynote speech on the nature of innovation, and lunch was provided by the Chamber of Commerce.

    a. Including a well-known keynote speaker to the event drew participants and generated a wider awareness of the event and SOF HUD.

    b. Major Lowry successfully used social media to broadcast the keynote speaker gaining international awareness of the event. This increased awareness of the event and resulted in several organizations from the US and the international tech industry have asked about the model and how well it was able to solve a complex problem. They expressed interest in participating or hosting events based on the SOF HUD Hackathon model.

    c. Recommendation: add an event like this in all future events to increase the "specialness" of the event by pairing professional and personal development in order to gain more broad participation and continue creating an innovation ecosystem.

6. Saturday's workday was when many of the breakthroughs were achieved. While several tasks/features were not able to be ported to the AR glasses, they were added to the Unity environment and should be able to display on the SOF HUD with more programing. The features the team successfully added are listed below:

a. Integration of the GPS feed from the Android device and displaying on the smart glasses

b. Ability to add waypoints and maintain proper scale (displaying an icon that increased in size as you approached it, while not having it too large)

c. Display of range and bearing over user inputted targets

d. Incorporation of 3D mapping in computing routes for the mini map, i.e.

not trying to route someone through a building.

    e. Streaming the AR wearer's view with symbology via Wi-Fi connection to an off-board display.

7. Sunday was spent by the team preparing the briefing and demonstration.

C. Conclusions and Way Forward:

1. Hackathon Model:

a. The model provides an extremely inexpensive and fast way to test a new technological idea using COTS and see if it is worth pursing with more resources.

b. With an outlay of only $15K for three DAQRI Smart Glasses, the USAF now has a prototype demonstrator SOF HUD and knowledge of what would be required to field an actual battle ready device.

c. The hackathon model successfully brought together individuals with a wide variety of experience and backgrounds together to address a problem that would have cost over $300,000 for a government agency to program and taken over six months to create the prototype demonstrator.[52]

d. Traditional means of developing a new technology like this would have required an initial budget, contract and bids to explore the feasibility of the idea itself. This would have taken considerably more time and money than using the hackathon.

e. Additionally, the hackathon strengthened the civ-mil relationship between the USAF and Montgomery. It gave our citizens a chance to work on a problem in support of national defense which was a significant motivator for many of the participants of the hackathon.

f. Capt Henicke, observed, "By creating an environment that encouraged innovation, the event also demonstrated the use of crowd-sourced development for future systems. Volunteers motivated intrinsically by the chance to learn and continue working on this project provided the manpower key to the success of this project. The environment, or 'ecosystem,' created by organizers enabled the cross-flow of participant's ideas across various disciplines and backgrounds."

2. SOF HUD is a viable technology and could be rapidly fielded is adequate resources are dedicated to development. Making this research a program of record with dedicated funds, time, expert programming, and field testing would result in a testable SOF HUD within in six months. I advocate we embed the development team with the field testing unit and refine the technology and concepts rapidly. This should result in an IOC system in under 10 months. By 12 months from start, the SOF HUD could be networked into existing systems and be ready for FOC certification.

3. By the end of the hackathon, a self-identified teams coalesced around task areas and created individual parts of the SOF HUD before putting them together in a working prototype. The prototype SOF HUD to act as a technology demonstrator to spur further funding and dedicated production efforts. Future efforts using a hackathon model could be used to identify star performers for recruitment. This would further attract more talented people and further accelerate DoD-sponsored technological innovation.

D. Recommendations:

1. Hackathon Model: This method of producing technology should be further developed and adopted by the DoD to accelerate fielding of new ideas, technology and exploit an untapped source of highly talented individuals to solve our wicked problems.

   a. The DoD should adopt hackathons at all levels of the DoD, from base-sponsored events that focus on local problems to Service-sponsored events to create solutions for large-scale, national-level problems.

   b. SECAF should create a networked office at USAF/HQ that centrally tracks and assists with these events at all levels to 1) avoid unnecessary duplication of effort 2) create synergy with similar problems and solutions 3) use spinoffs from these events to create new events and solutions proactively 4) match successful solutions to the appropriate level of resources to capitalize on innovation 5).

2. SOF HUD: The prototype created during the hackathon proved AR can quickly be adapted to battlefield use with little time required for development. Both air and ground SOF have expressed enthusiasm for AR's possibilities. Applications range from enhanced/augmented training in real-world settings to truly networking all weapon systems to the individual solider. Developing this technology will provide the US with new asymmetries in national defense.

   a. It needs to be adopted as a program of record with a dedicated team to program, test and field the technology as well as collaborate with end users to discover new and creative ways to utilized AR. We must also capture the ideas for spin-off technology and ideas that result from this process.

   b. With dedicated development and resources (i.e. a team of programmers, industry partners to modify hardware as necessary, and end user support) an IOC unit could be created in under 10 months of intensive development.

   c. Push awareness of AR and its possibilities to the force through outreach. Showcase SOF HUD as an example of AR's wide utility and adaptability.

      1. To take advantage of this the USAF, should advertise the capabilities of AR around the USAF and DoD to identify stakeholders who would benefit from AR and work with them to create a plan to implement AR operations for their unique mission set.

      2. AR is a low cost to entry solution that can solve many of the challenges facing individual units with unique mission sets. It has universal application and its adoption will assist in making the US Military an information age force that is able to take advantage of our unparalleled ability to conduct networked warfare.

//SIGNED//
C. CHRISTIAN LOWRY, Major, USAF

Appendix B: DAQRI Smart Glasses Spec Sheet

DAQRI SMART GLASSES™

SPECIFICATIONS

HARDWARE	
DAQRI Smart Glasses Weight	335g
DAQRI Compute Pack™ Weight	496g
Processor	6th Gen. Intel® Core™ m7 Processor (Up to 3.10 GHz) Dedicated vision processing unit for 6-DOF tracking
Optics	Dual LCoS Optical Displays 44˚ Diagonal FOV Resolution: 1360 X 768 Frame Rate: 90 fps
Connectivity	Wifi 802.11 a/b/g/n/ac 2.4/5 GHz Bluetooth
Battery	Built in rechargeable lithium ion battery 5800 mAh
Storage	64 GB Solid State Drive
I/O Ports	2 USB Type-C Ports 3.5mm Headphone Jack
Audio	2 Beamforming Mics with Active Noise Cancellation
Depth Sensor Camera	Range: 0.4m to 4m Resolution: 640 x 480 Frame Rates: 30, 60, 90 fps
Color Camera	1080p HD Camera, 30 fps
AR Tracking Camera	166˚ Diagonal Wide-Angle Fisheye Lens Resolution: 640x480 Frame Rate: 30 fps

VISUAL OPERATING SYSTEM	
Tools	Vos™ Extension for Unity
Apps	Camera, Gallery, Remote Expert

CERTIFICATIONS + STANDARDS	
Agency Certifications	United States (FCC) Canada (IC) European Economic Area (CE)
Eye Protection	ANSI Z87.1 (Eye and Face Protection) EN166 1S (Highest Optical Class, Increased Robustness Eye Protection) EN167 (Optically Tested Eye Protection)
Operating Range	Operating Temperature: 0 - 30° Designed for Indoor and Outdoor Use

IN THE BOX

· DAQRI Smart Glasses
· DAQRI Compute Pack
· USB Type-C Cable
· USB Type-C Power Supply
· Carrying Case with Shoulder Strap
· Padding Insert
· Cleaning Cloth
· Getting Started Guide
· Health and Safety Warnings

Appendix C: Capt Brad Henicke's Trip Report

DEPARTMENT OF THE AIR FORCE
1ST SPECIAL OPERATIONS WING (AFSOC) HURLBURT FIELD FLORIDA

23 Jan 18

MEMORANDUM FOR 319 SOS/CC

FROM: 319 SOS/DOFB

SUBJECT: SOF HUD Project Trip Report

1. From 14-17 Dec 17, I attended the SOF HUD event sponsored by Air University at CoWerx46 in Montgomery, Alabama. Maj Christian Lowry, ACSC Student and Project Lead, requested I attend as a subject matter expert bringing my perspective as a SOF aviator and experience from my graduate-level engineering fellowship research. The goal of the project was to determine whether commercial off-the-shelf augmented reality (AR) technology could be used to assist Special Operations Forces (SOF). Approximately 20 volunteers spent two days learning and integrating with some of the world's first production DAQRI Smart Glasses. Attendees then developed software that would demonstrate the utility of AR to the warfighter in the field. The cost to the US government was minimal, namely consisting of the cost of three pairs of glasses and my travel expenses. In a little over two days, attendees created and presented a working prototype for ground forces that successfully demonstrated the future potential of AR for SOF.

2. Despite recent advances in warfighting technology, the sharing of real-time battlefield situational awareness among air and group forces remains a challenge. Technology in the field of AR shows great potential for solving this problem by creating a shared consciousness among SOF operators/components and the conventional forces they fight beside. Emerging AR technology, already available on the commercial market, is capable of providing the wearer with a visual depiction of data from the real-world, similar to an aircraft heads-up display. It can also display visual representations of a virtual world. In the field, the shared consciousness provided by AR reduces the translations required as information is communicated across various mediums. Eliminating these translations reduces the time needed to communicate a message as well as the potential for errors from translations between mediums. Moreover, AR capabilities have immense potential for reimagining how we approach training across all career fields and SOF components. From interactive reference publications that guide the student through checklist steps to detailed virtual mission rehearsals, leveraging AR technology would revolutionize the way we approach training and combat readiness. Future development will need to address the myriad of challenges associated with fielding this technology, such as ruggedness, networked communication among devices, and interoperability with already fielded systems. In this event, time and resource constraints limited the scope to prototype design specifically for SOF ground forces, but a prototype of an aircrew version holds similar potential. Despite these challenges, the level of success reached at this event in such limited time shows great

promise for this technology in the near future. Further investment in its development is warranted to ensure we maintain America's technological advantage across the spectrum of conflict— especially for the nation's elite SOF.

3.   Today's rapidly evolving threat environment and innovation in the technological sector quickly renders systems that are not equally agile and adaptable obsolete. In addition to the demonstration of AR technology, the event also validated the use of crowd-sourced development for future systems. The SOF HUD event capitalized on volunteers who were motivated intrinsically by placing them in an environment that encouraged innovation. The environment, or "ecosystem," created by organizers enabled the cross-flow of ideas among participants from various disciplines and backgrounds. A facilitator led the project through Scrum, a management style with origins in software development. A subset of Agile, Scrum provides a basic framework for organization and encourages collaborative solutions rather than the more traditional focus on formal processes, organizational management or extensive documentation. The underlying principles of this form of project management were key to the progress made by participants in so little time with minimal formal organization. Widening our aperture to consider non-traditional approaches to leadership, organization and problem solving may prove worthwhile in attempting to solve a wide-range of problems from acquisition of future systems to retention of our highly trained and specialized members.

4.   I have provided attachments to further illustrate the project and its success. For additional information, please feel free to contact me by phone at (850) 881-3122 / DSN 641-3122 or via email at bradley.henicke.1@us.af.mil.

BRADLEY J. HENICKE, Capt, USAF
Mission Aircraft Commander, 319 SOS

2 Attachments:
1.   Major C. Christian Lowry ACSC Independent Study Proposal
2.   Event Photos

Appendix D:
Independent Study Research Proposal
Major C. Christian Lowry

- **Sponsor**: <u>Lt Gen Kwast and Maj Gen Leahy</u>

- **Working title**: "Enhanced Battlefield Awareness of Air-to-Ground Information with Augmented Reality (AR), Special Operations Forces Heads-Up Display (SOF HUD)"

- **Topic:** The SOF HUD will be a new technology and application to help maintain the US technological edge on the battlefield and has large implications on how the US presents SOF.

- **Preliminary Research Question**: In what ways can improved heads-up display capabilities using AR technology decrease cognitive load on the battlefield and improve efficiency and lethality?

- **Proposed thesis statement:** Integration of AR capabilities with HUD technology can enhance battlefield awareness and save lives.

- **Methodology**: The research on cognitive load and future use will be conducted through academic research and interviews with leaders in that field. Additionally, a prototype will be created using commercial-off-the-shelf (COTS) technology and existing AFRL and DoD programs (such as ATAK, LINK-16, etc…). Ultimately, the prototype will be tested under field conditions to validate the technology and plot an implementation strategy.

- **Problem Background:** Modern SOF require air-to-ground integration; however, streamlined integration has proven elusive. The USAF focus on on 5th-generation aircraft and C4ISR has typically neglected ground force integration, creating asymmetric capabilities and retarding air-ground integration. This capability gap will hamper the US SOF's ability to wage war as an integrated air-ground team.

  - Current TTPs use antiquated and inefficient technology to present vital information on the battlespace. Consider US reliance on voice communications describing what an air asset sees: Ground Force Commanders are reduced to making decisions based on a "telephone game." They must interpreted and orient paper products and mentally overlay them on the battlespace. This is mentally intensive and requires mastery of a difficult skillset. Few are able to master this complex set of tasks, particularly under the stresses of combat.

  - *AR will bridge this gap by making integration more seamless and intuitive, allowing warfighters to process more information and become more effective*. For too long US forces have been playing a game of telephone between ground and air forces. This has resulted in increased fog and friction on the battlefield as well as costly errors.[53]These errors have cost lives and eroded freedom of action on the

    battlefield by disrupting US relationships with partner nations and hurting US prestige in world opinion. Using AR will reduce errors by presenting identical information to both air and ground forces in an intuitive way. It will provide more information than is currently processed, and thus help reduce the fog and friction of war.

- This research seeks to create a prototype of a SOF HUD by using AR to integrate situational awareness tools currently used by SOF. Using the SOF HUD will allow users to access a massive amount of data in an intuitive way and enhances their battlefield awareness while creating a more seamless integration between air and ground forces. This will increase the US' technological advantage and enhance lethality.

- AR presents information in an intuitive way, allowing the human mind to process more data by reducing extraneous cognitive workload.[54] This enables users to synthesize data more quickly and in a more sophisticated manner. This in turn increases cognitive capacity, allowing users to process more information more quickly to make better decisions thus reducing the fog and friction of war.

- With simple AR holograms superimposed on the actual battlespace, vast amounts of information can be intuitively processed without cognitive overload. As more information is processed, users will gain enhanced situational awareness, reduce radio communications, accelerate decision making and increase mission efficacy.

- The research will have three focus areas:

  1. Decreasing extraneous cognitive load by presenting information in an intuitive and visual way by exploiting Human Native Form
  2. Describing and justifying the design and functionality of this new technology (i.e. create a taxonomy and ontology to inform users how to leverage this technology in battlefield situations)
  3. Creating a device, worn by ground forces that leverages AR to present air-ground information

- The prototype will leverage existing COTS technology, but will be equipment agnostic. The goal is to produce a working prototype as a proof of concept and allow creation of TTPs. Existing systems in current inventory will be used to the greatest extent possible:
    - ATAK/TransAPPS (DARPA)
        - Open-code battlefield and training apps used by DoD
    - Smart Glasses/Smart Helmet (Unity Based Software)
        - Exploring the creation of a ballistic safe and NVG compatible AR Headset
    - L3 Force X software suite (i.e. Sentry, Brimstone, etc.…)
    - RAAF & SAAB AU's Project Jericho and Sandbox Software

- **Sources**: Thus far, this researcher has developed the following list of contacts. The

listed organizations and individuals have agreed to be part of the research and steering team to bring this technology online. They are listed by name and with a description of their proposed contribution(s).

- Doran Michaels VP of Defend Tex USA
  - Formerly DARPA's TransApps PM, opening his network from his time at DARPA, helping to explore 3D audio
- GXM Consulting
- Working on a host of Android apps for TransApps (DARPA initiative)
- Air Force Research Lab, Gaming Research and Integration Learning Laboratory
  - Massive experience with Unity programing language and human-machine interface
- Luke Savoie: GM and VP of L3 ForceX
  - Work AFSOC/SOCOM ISR and FIRES software, integrate airborne data into system for functionality
- Army Gaming Studios
  - World-class simulations and graphic production, and applications programming
- USMC Deputy Commandant for Aviation
  - MAGTF Distributed Interoperability and innovation partnership
- DAQRI
  - Developed a smart-lens for industrial applications and are exploring making it ballistic safe and NVG-compatible
- RAAF & SAAB Australia
  - Willing to share what they have created and how to support this effort
- Lt Col Dave Blair, OSD/OUSD Policy
  - Key member or steering team and helping with the future use of this technology.
- DARPA
  - Leveraging their experience with TransApps and a Google Glass type prototype
- Lt Col Jeffrey R. LaFleur, Materiel Leader, Integrated Strike Programs HQ USSOCOM, SOF AT&L-FW
  - Allowing access to existing SOCOM initiatives what will integrate into the prototype
- Stephanie Wander: Senior Prize Developer, X-Prize; Professor, University of Southern California
  - Provides project with general consulting and guidance with technology industry as well as ways to incorporate disruptive technologies with legacy systems
- Marcus Anzengruber: AR and Virtual Reality entrepreneur, NASA and DoD consultant
  - Well connected AR insider with ability to network and source best technology for inclusion into SOF HUD project

Appendix E: Event Photos
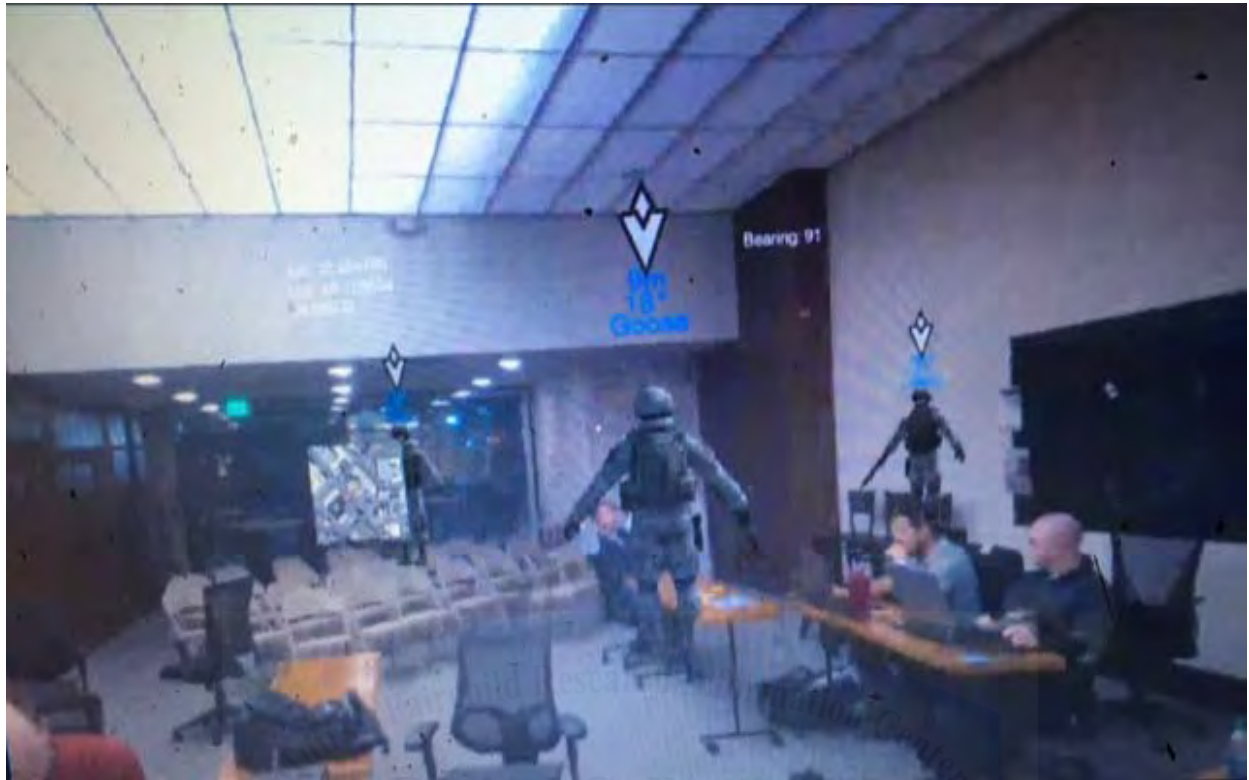
Endnotes:

1 Hugh D. Hindman, *Child Labor: An American History* (Armonk, NY: M. E. Sharpe, 2002), 13-17.

2 Richard T. Ely, et al, *Outlines in Economics, 3ʳᵈ ed* (New York, NY: Macmillan, 1919) 62.

3 Hindman, *Child Labor*, 17.

4 Ibib, 22-23.

5 Eric A. Hanushek and Ludger Woessman, *The Knowledge Capital of Nations: Education and the Economics of Growth* (Cambridge, Mass: The MIT Press, 2015) 1.

6 Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (Oxford, UK: Clarendon Press, [1776]1979) 118.

7 Eric A. Hanusek, *The Knowledge Capital of Nations*, 1.

8 Hanushek and Woessmann offer statistics that show countries with more educated populations experienced more growth in "skill-intensive industries" in the 1980s and 1990s. They posit that more skilled people adapt and adopt new technologies more readily which leads to faster innovation and ideas as well as technological diffusion and growth. Consider this the push-pull of education and innovation driven by a desire to produce and consume ever larger amounts. Ibid, 106-107.

9 Alec Ross, *The Industries of the Future* (New York, NY: Simon & Shuster, 2016) 152.

10 Gregory Clark, "The Agricultural Revolution and the Industrial Revolution: England, 1500-1912" (University of California, Davis, CA: University of California Press, 2002), 3, www.econ.ucdavis.edu/faculty/gclark/papers/prod2002.pdf.

11 Ibid, 9.

12 Historical Timeline — Farm Machinery & Technology https://www.agclassroom.org/gan/timeline/farm_tech.htm.

13 Ibid,.

14 Sam Ro, "Here's a Price List For a Whole Bunch of Cool, Brand New Farm Equipment," *Business Insider,* May. 8, 2014, http://www.businessinsider.com/farm-equipment-prices-2014-5

15 Alec Ross, *The Industries of the Future* 162.

16 Ibid,.

17 "Data" Merriam-Webster.com, accessed February 10, 2018. https://www.merriam-webster.com/dictionary/data.

18 James Gleick, "The Information Palace" nybooks.com, December 8, 2010, http://www.nybooks.com/daily/2010/12/08/information-palace/.

19 9,400 words equals 39.8 pages if it is double spaced, 12pt font, Times New Roman

20 Ibid,.

21 To this day many abhor the study of history as an exercise in memorizing dates and places. This is a legacy of industrial age instruction. Under that system there is little to be gained from a deeper understanding of historical context and how events grew from its antecedent or how that event influences future events. Unfortunately, lower level math is still taught this way. Few teachers dive into why the additive property is important or different than the multiplicative property, and few students could describe the utility of a sine or cosine…

22 Ibid,.

23 Ibid,.

24 "Information," *Merriam-Webster,* Accessed February 10, 2018. https://www.merriam-webster.com/dictionary/information.

25 Peter Carlson, "The Flop Heard Round the World," *Washington Post*, September 4, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/09/03/XXXX.html

26 Ibid.

27 Ibid.

28 "How Does the Brain Process Information?" *Teachnology.com*, accessed February 9, 2018. http://www.teach-nology.com/teachers/methods/info_processing/.

29 Ibid.

30 Ibid.

31 Ibid.

32 Robert Epstein, "The Empty Brain," *Aeon Essays*, May 18, 2016, https://aeon.co/essays/your-brain-does-not-process-information-and-it-is-not-a-computer.

33 Ibid.

34 Anthony Chemero, "Radical Embodied Cognitive Science," *Review of General Psychology* 17(2), 145-150. http://dx.doi.org/10.1037/a0032923

---

[35] Sy Mukherjee "These DNA 'Nanobots' Could Help Kill Cancer By Choking Off Its Life Blood," *Fortune.com,* February 13, 2018, http://fortune.com/2018/02/13/dna-nanobots-cancer-tumors/.

[36] From the Authors interview with SOCOM Chief of Staff, Major General James Slife, November 2017.

[37] Rachel Will, "China's Stadium Diplomacy" *US-China Today,* 11 October 2011, http://www.uschina.usc.edu/w_usct/showarticle.aspx?articleID=17566&AspxAutoDetectCookieSupport=1.

[38] "Deep Space Industries," Accessed 30 March 2018, http://deepspaceindustries.com/mining/

[39] Salim Bitam, Mohamed Batouche, El-Ghazali Talbi, "A survey on bee colony algorithms," Parallel & Distributed Processing Workshops and Phd Forum (IPDPSW) *2010 IEEE International Symposium*, pp. 1-8, 2010.

[40] "Solving The Bee Crisis With Machine Learning," *The Innovation Enterprise*, 28 June 2017, https://channels.theinnovationenterprise.com/articles/solving-the-bee-crisis-with-machine-learning.

[41] Col Gjert Lage Dyndal, Lt Col Tor Arne Berntsen and Sigrid Redse-Johansen, "Autonomous military drones: no longer science fiction," *NATO Review Magazine*, 28 August 2017, https://www.nato.int/docu/review/2017/Also-in-2017/autonomous-military-drones-no-longer-science-fiction/EN/index.htm

[42] Cheryl Pellerin, "Hagel Announces New Defense Innovation, Reform Efforts," *Defense.gov*, 15 November 2014, https://www.defense.gov/News/Article/Article/603658/.

[43] "War Production", *PBS.org,* September 2007, *http*://www.pbs.org/thewar/at_home_war_production.htm.

[44] Steven Stahwick, "US Navy, Marine Corps Unveil New Strategy to Turn Tables on A2/AD," *The Diplomat,* 2 October 2017, https://thediplomat.com/2017/10/us-navy-marine-corps-unveil-new-strategy-to-turn-tables-on-a2ad/.

[45] Koh Swee Lean Collin and Ngo Minh Tri, "Learning from the battle of the Spratly Islands," *The Diplomat,* 20 March 2018, https://thediplomat.com/2018/03/learning-from-the-battle-of-the-spratly-islands.

[46] Sean O'Neil, "Human vs Machine: Five epic fights against AI," *New Scientist,* 31 May 2017, https://www.newscientist.com/article/2133146-human-vs-machine-five-epic-fights-against-ai/.

[47] Yuval N Harari, *Homo Deus:* A Brief History of Tomorrow. 2016 (p. 97)

[48] Homer, Lattimore, R. (ed.) (1967). *The Odyssey of Homer*. New York: Harper & Row.

[49] Lindley C.A. (2012) "Synthetic Intelligence: Beyond Artificial Intelligence and Robotics." In: Simeonov P., Smith L., Ehresmann A. (eds) *Integral Biomathics: Tracing the Road to Reality*. Springer, Berlin, Heidelberg

[50] From author's interview with USASOC Human Performance Directorate 2016, Ft. Bragg, NC

[51] Terrence Kelly, Ralph Masi, Brittian Walker, Steven Knapp, Kristin Leuschner, *An Assessment of the Army's Tactical Human Optimization, Rapid Rehabilitation and Reconditioning Program* (Santa Monica, CA: RAND Corporation, 2013) https://www.rand.org/pubs/technical_reports/TR1309.html.

[52] Cost based on quote from Army Gaming Studios in 2016.

[53] The MSF Hospital shooting in Kunduz, Afghanistan is an example of this: The crew of the AC-130U and ground force incorrectly identified the MSF compound as the target called in by Afghan partner units despite the hospital being several kilometers from the intended target. This was, in a large part, to the crew of the AC-130 using vague confirmation descriptions over the radio to the JTAC who authorized the strike. This could have easily been avoided with better coordination through the use of Augmented Reality as proposed in this research proposal.

[54] Arthur Tang, Charles Owen, Frank Biocca, and Weimin Mou. 2003. Comparative Effectiveness of Augmented Reality in Object Assembly. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '03). ACM, New York, NY, USA, 73-80. An experiment used AR to aid a lego building task. . The results show an 82% decrease in errors and a marked reduction in mental load. They authors conclude that some of the cognitive load is offloaded to the AR system.

Bibliography:

Bitam, Salim, Mohamed Batouche, and El-Ghazali Talbi. "A survey on bee colony algorithms." *Parallel & Distributed Processing Workshops and Phd Forum (IPDPSW) 2010 IEEE* International Symposium, 2010.

Carlson, Peter. "The Flop Heard Round the World." *Washington Post*, 4 September, 2007. http://www.washingtonpost.com/wpyn/content/article/2007/09/03/XXX.html.

Chemero, Anthony. "Radical Embodied Cognitive Science." *Review of General Psychology*, 17 no. 2 145-150.

Clark, Gregory. *The Agricultural Revolution and the Industrial Revolution: England, 1500-1912*. University of California, Davis, CA: University of California Press, 2002, http://www.econ.ucdavis.edu/faculty/gclark/papers/prod2002.pdf.

Collin, Koh Swee Lean, and Minh Tri, Ngo. "Learning from the battle of the Spratly Islands." *The Diplomat*, 20 March 2018, https://thediplomat.com/2018/03/learning-from-the-battle-of-the-spratly-islands.

"Deep Space Industries," Deep Space Industries. Accessed 30 March 2018, http://deepspaceindustries.com/mining/.

Dyndal, Col Gjert Lage, Lt Col Tor Arne Berntsen, and Sigrid Redse-Johansen. "Autonomous military drones: no longer science fiction," *NATO Review Magazine*, 28 August 2017. https://www.nato.int/docu/review/2017/Also-in-2017/autonomous-military-drones-no-longer-science-fiction/EN/index.htm.

Ely, Richard T. et al. *Outlines in Economics.* 3rd ed. New York, NY: Macmillan, 1919.

Epstein, Robert. "The Empty Brain." *Aeon Essays*, 18 May, 2016, https://aeon.co/essays/your-brain-does-not-process-information-and-it-is-not-a-computer.

Gleick, James. "The Information Palace." *New York Books*, 8 December, 2010. http://www.nybooks.com/daily/2010/12/08/information-palace/.

Hanushek, Eric A., and Ludger Woessman. *The Knowledge Capital of Nations: Education and the Economics of Growth*. Cambridge, Mass: The MIT Press, 2015.

Harari, Yuval N. *Homo Deus: A Brief History of Tomorrow*. New York: McClelland & Stewart, 2016.

Hindman, Hugh D. *Child Labor: An American History*. Armonk, NY: M. E. Sharpe, 2002.

Homer, Lattimore, R. (ed.) *The Odyssey of Homer*. New York: Harper & Row, 1976.

Kelly, Terrence Masi, Ralph Brittian Walker, Steven Knapp, and Kristin Leuschner, *An Assessment of the Army's Tactical Human Optimization, Rapid Rehabilitation and Reconditioning Program*. Washington, DC: RAND Corporation, 2013. https://www.rand.org/pubs/technical_reports/TR1309.html.

Lindley, C.A. "Synthetic Intelligence: Beyond Artificial Intelligence and Robotics." In *Integral Biomathics: Tracing the Road to Reality*. Edited by: Simeonov P., Smith L., Ehresmann, A. Berlin: Springer, 2012.

Merriam-Webster. "Data." *Merriam-Webster Online*. Accessed 10 February, 2018. https://www.merriam-webster.com/dictionary/data.

Merriam-Webster. "Information." *Merriam-Webster.com*. Accessed 10 February, 2018. https://www.merriam-webster.com/dictionary/information.

Mukherjee, Sy. "These DNA 'Nanobots' Could Help Kill Cancer By Choking Off Its Life Blood." *Fortune*, 13 February, 2018, http://fortune.com/2018/02/13/dna-nanobots-cancer-tumors/.

National Agricultural Classroom (USDA). "Historical Timeline — Farm Machinery & Technology." Accessed 6 January 2018. https://www.agclassroom.org/gan/timeline/farm_tech.htm.

O'Neil, Sean. "Human vs Machine: Five Epic Fights against AI." *New Scientist*, 31 May 2017, https://www.newscientist.com/article/2133146-human-vs-machine-five-epic-fights-against-ai/.

Pellerin, Cheryl. "Hagel Announces New Defense Innovation, Reform Efforts." *Defense.gov*, 15 November 2014, https://www.defense.gov/News/Article/Article/603658/.

Ro, Sam. "Here's A Price List For A Whole Bunch Of Cool, Brand New Farm Equipment." *Business Insider*, 8 May, 2014. http://www.businessinsider.com/farm-equipment-prices-2014-5.

Ross, Alec. *The Industries of the Future*. New York, NY: Simon & Shuster, 2016.

Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Oxford, UK: Clarendon Press, [1776]1979.

"Solving The Bee Crisis With Machine Learning." *The Innovation Enterprise*, 28 June 2017. https://channels.theinnovationenterprise.com/articles/solving-the-bee-crisis-with-machine-learning.

Stahwick, Steven. "US Navy, Marine Corps Unveil New Strategy to Turn Tables on A2/AD." *The Diplomat*, 2 October 2017, https://thediplomat.com/2017/10/us-navy-marine-corps-unveil-new-strategy-to-turn-tables-on-a2ad/.

Tang, Arthur, Charles Owen, Frank Biocca, and Weimin Mou. "Comparative Effectiveness of Augmented Reality in Object Assembly." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*, New York, NY: ACM, 2003.

Teach-nology. "How Does the Brain Process Information?" Teachnology.com. Accessed 9 February, 2018. http://www.teach-nology.com/teachers/methods/info_processing/.

"War Production." Public Broadcasting Service, September 2007, http://www.pbs.org/thewar/at_home_war_production.htm.

Will, Rachel. "China's Stadium Diplomacy." *US-China Today*, 11 October 2011, http://www.uschina.usc.edu/w_usct/showarticle.aspx?articleID=17566&AspxAutoDetect CookieSupport=1.