# The Integration of Unmanned Aerial Vehicles (UAVs) in Offensive Combat Situations

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11 May 2004

# Overview

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# Motivation

- UAV Capabilities
  - Reduced radar signature, increased endurance, and potential for cost reduction
  - Absence of human pilot
  - Applicable to offensive missions, where pilot's taskload is high
- Trends
  - Seven UAV systems deployed in OIF
  - Analysts predict 16 fully operational UAV programs in 10 years
  - 75% of recent Predator accidents due to human/UAV interaction
- Manned Aircraft Control of UAVs
  - Reduced datalink vulnerability (Howitt, 2003)
  - Decrease in data transit time
  - Visual confirmation of UAV actions and targets possible

-UAVs are typically smaller than manned aircraft, have a reduced radar signature, and increased endurance. There is also a large potential for cost reduction. The absence of a human pilot allows them to be more maneuverable, avoid the equipment and systems usually needed to support a human pilot, and stays away from the politically unattractive risk of putting humans in dangerous situations. They have proven their worth in intelligence, surveillance, and reconnaissance missions, but have shown a large potential for offensive missions, where the pilot's taskload is very high.
-There were seven different UAV systems deployed in Operation Iraqi Freedom and analysts predict that there will be 16 fully operational UAV programs in the next 10 years. Also, 75% of recent Predator accidents were caused by the interaction between the human controller and the UAV. Although much of those accidents resulted from problems with manual control, some were the result of problems with the human/machine interface.
-Control of a formation of UAVs from a manned, lead aircraft might eliminate some of these problems and bring about new benefits. There would be less of a chance for data or images sent to be lost or intercepted in transit. There would be a decrease in that transit time, and visual confirmation of the UAV's actions and targets would be possible.

# System Configuration

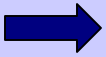
UAV
Position #4

DoD photo by Petty Officer 3rd Class Jeffrey S. Viano, U.S. Navy

UAV
Position #3

U.S. Air Force photo by Tech. Sgt. Orville Desjarlais

Manned, Lead Aircraft
Position #1



One Possible UAV/Manned System Configuration

UAV
Position #2



(Source: Schmitt, F-16C Reference Library)

# Study Overview

- Created "UAV Status" display for lead aircraft
  - Screen sequence simulated a series of events
  - Used management-by-consent control approach
  - Composed an associated questionnaire
- Interviewed ten military pilots (due to deployments, wartime considerations, etc…)
  - Four A-10 pilots (single-seat)
  - Two F-16 pilots (single-seat)
  - Two AC-130 pilots (multi-crew)
  - Two Predator UAV pilots (no seats)
- Purpose:
  - Validate conclusions of past studies with expert analysis

-So, I created a "UAV Status" display that would be located in the cockpit of the lead aircraft. A screen sequence simulates a series of events on this display, and the simulated events follow a management-by-consent control approach, which essentially requires the UAV to make a recommendation for each decision and gain approval for that suggestion before acting upon it. I also created a questionnaire that goes along with the display.
-Using the questionnaire, I interviewed ten military pilots. Unfortunately, I was unable to gather more subjects because so many people are deployed to various parts of the world or performing mandatory training. However the pilots I was able to interview included four A-10 pilots, two F-16 pilots, two AC-130 pilots, and two operators of the Predator UAV, who also liked to be called pilots. So there was a fairly interesting mix of people involved.
-The purpose of this study was to validate some of the conclusions of past studies with expert analysis – the pilots

# Goals

- Primary goal:
  - Determine appropriate levels of pilot control and UAV/human interaction
- Secondary goals:
  - Discuss relative importance of different display characteristics to military pilots
  - Determine acceptance of UAVs within the military aviation community.

Note: Display was intended only to be the method by which expert analysis regarding the appropriate control methodology was obtained.

-The primary goal was to determine the appropriate level of pilot control over the UAV and the appropriate level of interaction between the human and the UAV.
-The secondary goals were to discuss the relative importance of different display characteristics and to determine the attitude towards UAVs within the military aviation community.
-As quick note, the display that I designed, which I will show you in a second, was not intended to be an actual prototype for a cockpit display. It was really only intended to be the method by which expert analysis regarding the appropriate control methodology was obtained.

# Methods

- Obtained background information
  - Name, rank, age, gender, branch of service, time in service, experience with UAVs
- Allowed each pilot to become familiarized with display
- Performed step-by-step questioning of major decisions throughout screen sequence
- Observed general attitude towards UAVs

-The method I used to gain the information needed was very simple. I first asked the pilots for background information, such as name, rank, age, and other things. I also asked them if they had any experience with UAVs. I had initially thought that the more experience a person had with UAVs, the more accepting he or she would be of UAVs in offensive combat roles. However, as I will show you later, this was not always the case.
-So, after getting background information, I gave each pilot some time to become familiarized with the display.
-Then, we navigated through the display, and I essentially questioned them about every step and every decision along the way. I was interested in what decisions they would want to make for themselves as well as what they would need to make the decisions or to let the UAVs make those decisions.
-Finally, I just observed their general attitude towards UAVs throughout the whole process.

# Cockpit Display

# Results

- Pilots were very accommodating
  - Interviews scheduled to last only 20-25 minutes but average interview time reached 45 minutes
- Three general areas of analysis
  - Control Methodology
  - Display Factors
  - General Trends

-It turned out that the pilots were extremely accommodating. The interviews were only supposed to last 20-25 minutes, but the average interview time turned out to be around 45 minutes.
-I'm going to discuss the results in three general categories. The first is the control methodology, then some display factors, and finally some overall general trends.

# Control Methodology

- Pilots would rather be given a recommendation to make a more informed decision than actually have the decision made for them
  - Example: UAV 3 obvious choice, but control still desired
- Continuously granting permission to UAVs for "tedious" requests would take away from other important tasks
  - Example: Letting UAV 3 leave the formation
- Never let UAV perform offensive action on its own
  - Example: Should not re-strike target after a miss
- Pilot must be "kept in the loop" for most actions
  - Wanted to examine "flow of battlefield" to determine best course of action

-After the first three questions, it became very obvious that the pilots would rather be given a recommendation to make a more informed decision than to actually have that decision made for them. One example was in the case of picking which UAV to select. UAV 3 was the obvious choice based on its sensor package, but the pilots still wanted the ability to choose a different UAV due to the munitions it was carrying, fuel, or other information.
-The pilots thought that having to continuously grant permission to the UAVs for "tedious" requests would take away from other important tasks. One example was after UAV 3 is selected to perform the mission. Some of the pilots still wanted the UAV to ask permission before leaving the formation, but most of them thought that it should just leave after being selected in order to cut down on unnecessary requests.
-The pilots were most afraid of having the UAV perform an offensive action on its own. They were afraid it would drop a bomb on civilians or otherwise cause some disaster. One example was when the UAV missed the target the first time, they definitely did not want it to automatically re-strike the target. They wanted to figure out what went wrong first – if it was a mechanical problem, if it they caused some type of collateral damage before letting the UAV go off and strike the target again.
-Many of the pilots mentioned that they wanted to be kept in the loop for most actions. The UAV should be able to maintain flight and do other simple things but the pilots need to be able to examine what they called "the flow of the battlefield" to make critical decisions.

# Control Methodology

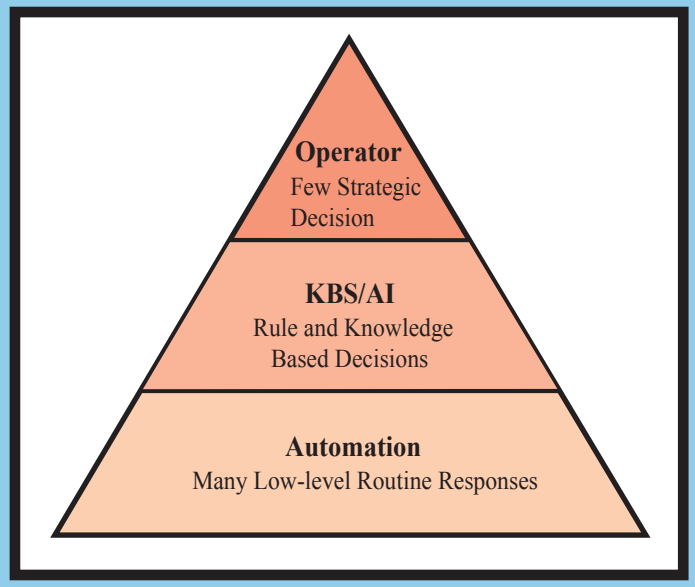
- Pilots' responses corresponded to approximately a Level 5 LOA and a medium level interaction.

LEVELS OF AUTOMATION

| Automation Level | Automation Description |
|---|---|
| 1 | The computer offers no assistance: human must take all decision and actions. |
| 2 | The computer offers a complete set of decision/action alternatives, or |
| 3 | narrows the selection down to a few, or |
| 4 | suggests one alternative, and |
| 5 | executes that suggestion if the human approves, or |
| 6 | allows the human a restricted time to veto before automatic execution, or |
| 7 | executes automatically, then necessarily informs humans, and |
| 8 | informs the human only if asked, or |
| 9 | informs the human only if it, the computer, decides to. |
| 10 | The computer decides everything and acts autonomously, ignoring the human. |

(Source: Sheridan et al., 1978.)

LEVELS OF INTERACTION




(Adapted from Howitt et al., 2003.)

-So the pilots' responses corresponded to approximately Level 5 on Sheridan's table, where the automation suggests one alternative and executes that suggestion if the human approves. The responses also corresponded to a medium level of interaction, where some simple functions, such as maintaining flight or defending itself, should be automated whereas making target selection or other decisions should be left to the pilot.

# Control Methodology

- Giving control of UAVs to lead manned aircraft is a good idea
  - Reduced time delay is critical for some key decisions
- Single-seat airplane control is not feasible
  - Additional tasks of flying an airplane too "overwhelming"
  - Dual-seat or multi-crew aircraft more appropriate
- UAVs should be mainly used for ISR, SEAD missions
- UAVs should not be used for all other missions, especially when near friendly forces

-Overall, the pilots thought that giving control of UAVs to lead manned aircraft is a good idea. They thought that the reduced time delay would be very helpful in making quick decisions in a combat situation and that it would be good to have a human being overseeing everything a UAV was doing.
-However, they all thought that control of UAVs from a single-seat airplane was not feasible. The additional tasks of flying an airplane and communicating things back to a ground station would be too "overwhelming," in the words of one pilot. They thought a dual-seat aircraft would be sufficient, and a multi-crew aircraft would have plenty of people.
-With regard to missions, the pilots thought that the UAVs should mainly be used for ISR or SEAD missions. They thought UAVs wouldn't even work in a pre-planned strike mission, because the situation might have changed substantially during the time it took to take off and fly to the target area.
-They thought UAVs should not be used for any other missions, especially when supporting friendly forces on the ground.

# Display/Interface Factors

- UAV characteristics not needed on main screen
  - Pilots wanted ability to “click” on a UAV and bring up the associated attributes when needed
- Expand message/command window
  - Continuous scrolling down adds time and frustration
- Real-time video link preferred
  - More accurate picture of battlefield than snapshots
- DVI unreasonable due to pilot “slang”
  - Hand signals add to difficulty

-With regard to display or interface issues, the pilots thought that the UAV characteristics part of the display was unnecessary. They would rather have the ability to “click” on a particular UAV and bring up the associated attributes when needed.
-They thought the command/message window could be expanded quite a bit. They said that continuously having to scroll down just adds time and frustration to the whole process.
-They would definitely prefer a real-time video link because it would give them a more accurate picture of the battlefield than just snapshots, but they would take what they could get.
-Also, Direct Voice Input, they believed, was unreasonable given all the jargon and slang that pilots use. Also, they communicate a lot of the time with hand signals and other techniques that might be harder for a UAV to comprehend.

# General Trends

- Pilots interviewed not representative
  - Small sample size (10)
  - Average age was 39
  - Average time in service was 18 years
- UAV/multi-crew pilots were more accepting of role for UAV in offensive combat operation
- Fighter pilots less accepting of UAV role
- Every pilot liked the idea of using UAVs as an advanced tool or weapon, with decision authority given to pilot
- More detailed study with more representative test subjects could provide helpful framework to integrate manned and unmanned systems

-Now I'd just like to wrap up with some general trends that I noticed. First of all, the pilots that were interviewed cannot be taken to be representative of the entire military aviation community. The sample size was too small. The average age was 39 and the average time in service was 18 years. Thus, the views expressed may be more indicative of an older generation of pilots, no offense to the professors, who may possibly have less familiarity with UAVs or automated systems, and this may cause them to be less accepting of UAVs.
-There was a marked contrast between the opinions of the UAV and multi-crew pilots as compared to the single-seat fighter pilots. The first group seemed to be a little more accepting of the role of UAVs in offensive combat operations and seemed to realize that the integration of manned and unmanned systems was going to have to take place eventually. The fighter pilots, however, seemed much more hesitant to accept UAVs as an inevitable addition to the military, specifically in offensive operations. Interestingly enough, experience with UAVs turned these fighter pilots in the opposite direction. One pilot worked with UAVs in an exercise out at Nellis Air Force Base in Nevada. Groups of pilots were flying in different routes that were separated by ridge lines on the ground. However, during the exercise, a software malfunction on a nearby Predator UAV occurred, and the UAV proceeded to glide over a ridge into the flight path of the closest group of pilots. Control over the UAV was eventually regained, and nobody was hurt, but the pilot involved lost all his confidence in the technology behind UAVs, especially because the ridgelines separating the flight paths were quite obvious to any human being. He actually would like to have the ability to destroy any nearby UAVs if they operated anywhere outside of pre-approved plans, and that specific comment was repeated by naval aviators in interviews that Emily Craparo conducted a few months ago.
-Most pilots, however, liked the idea of using UAVs as an advanced tool or weapon, but giving the decision authority to the pilot. In fact, six out of ten pilots specifically referred to having these UAVs as a "capability" or "weapon."
-So to conclude, I would say that a more detailed study with a more representative group of subjects could build on the conclusions presented here and really provide a helpful framework to integrate manned and unmanned systems.

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Questions?