A Case for the Development of Models to Capture the Dynamical Responses to UAV Surveillance and Engagement Actions

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Goal of This Presentation

To make a case for the development of multi-dimensional mathematical dynamical models of individuals, groups of people, and nations, that would assist in autonomous decision-making processes.

Model variables would include operational, behavioral, economic, political and in addition to technical variables. Furthermore, they would be time-varying 'Bayesian' models that would take advantage of response data associated with prior responses while incorporating current and future anticipated climates related to these variables.

A Hypothetical Scenario- Companies A and B are bidding on a UAV contract with the military. The technological elements of both bidders are comparable.

Company B also claims that their UAVs integrate sensing information with a post-processor for phase I assessment and risk analysis [information that is intended to aid the controller to assess the situation not only more quickly, but also in a broader context.]

Example: The detection and classification of a user-controlled 'fixed gaze' potential target is assessed as follows: child/adult , male/female , carrying/not carrying a given type of weapon. Each of these is reported to the controller, and each includes a probability of being wrong. Furthermore, the system is able to develop a profile of the environment the potential target is in: local population density/density class composition/sensitive facilities/etc. Moreover, this profile is dynamic; that is, it is updated and able to predict traits of populace and individual behavior that are considered normal within a prescribed temporal/spatial environment. In this way, if the prediction error should make a significant jump over a short period of time, the controller would be more likely to be especially watchful. And finally, it is able to utilize an on-board dynamic data base to convey information related to past actions in the given sector, and in similar environmental situations. This includes not only at-the-time information, but also information related to the repercussions of past actions (not only military, but political, economic, and locally/nationally/internationally significant re: public opinion, human rights, etc.)

Question: Do you think Company B will have any advantage?

Suppose that both bidders offer such information. But Company B also provides information associated with the potential consequences of an action to be taken by the controller. Specifically, it is able to run multiple model simulations designed to assess the risk entailed in taking a specific action; *multi-dimensional risk* that is defined in multiple space/time scales.

Question: Do you think Company B will have any advantage?

Fact: UAV controllers need all the help they can get, in order to make well-informed but rapid decisions.

[1] FY2009-2034 Unmanned Systems Integrated Roadmap U.S. DoD

[2] USAF Unmanned Aircraft Systems Flight plan 2009-2047 :

"… performance should evolve from today's controller to platform ratio of many to one or at best one to one, to a single controller being able to monitor multiple unmanned systems performing across domains as collaborating teams."

"Because unmanned systems will progress further and further with respect to full autonomy, on-board sensors that provide the systems with their own organic perception will be able to contribute to Battle Space Awareness regardless of their intended primary mission."

"The human commander will be able to control a group of heterogeneous robots through a smart "squad leader" robot. The lead robot takes high-level plans and goals from the human commander, then formulates the detailed plans, tasks, and monitors other more specialized robots to perform the work. The specialized robots would have varying capabilities and mobility modalities, e.g., wall climbing, flying, ground traversing, underwater swimming, and various modes of manipulation, etc. The lead robot uses its processing power to assume the work of a large number of individual robot operators."

Definition 1. By **responsible development**, is meant, development that recognizes and genuinely attempts to accommodate the

*** military/social/cultural/economic/political/legal ***

systems framework in which it is couched, in a manner that demonstrates respect for the welfare of all parties.

My Personal Observation: Other than the above very general quotes, I could find nothing of any explicit substance in either [1] or [2] that addresses the following question:

Question: *Is it reasonable, or even desirable that UAV developments over the next 25 years should include responsible development?*

Yesterday: In his talk, entitled *"The Challenges Awaiting Governments Over the UAV Quest"* Yasar Gurbuz suggested that governments should take the lead in addressing challenges related to killing civilians or bombing schools.

In This Talk: I will argue that

1. It is in the best interest of UAV industries to take lead.

2. The responsible development of UAVs should be conducted in a statistical dynamical systems framework.

2. An Argument for Responsible Development of UAVs

***Definition* 2.** *A **dynamical systems framework** is a framework wherein the 'inputs' and outputs' that are the defining elements of the system are sufficiently broad as to include not only technical variables, but also behavioral, social, economic, political, and legal variables, in relation to individuals, small groups, and populations. The framework is dynamic if it recognizes the temporal nature of these variables.*

Argument 1: Perhaps the strongest argument for **timely** responsible UAV development relates to their use in Afghanistan. General McChrystal stated [3]:

"We have shot an amazing number of people, but to my knowledge, none has ever proven to be a threat."

The accelerated use of drones to carry out such a missions will very likely compound the problem, since the cost does not include military casualties; hence, in that respect the risk is minimal. General McChrystal's assessment was not a pleasant one. But at least it suggested an honest acknowledgement that **there is a problem**, and that he is doing everything within his power to address it. Even so, there is **nothing** in the hallmark U.S. document [1] that lays out the roadmap in the development of UAVS over the next *25 years* that would support such a statement from a top military commander. In fact, one could argue that by *not* addressing this issue, [1] supports a claim that there is actually zero sensitivity to innocent deaths in relation to the use of drones. Hence, **one argument for formulating a policy on the responsible development of UAVs is that, at least there would be some semblance of genuine recognition of their use in a responsible manner.**

Argument 2: In the executive summary of [1] it is stated that:

"As of October 2008, coalition unmanned aircraft systems have flown almost 500,000 flight hours in support of Operations Enduring Freedom and Iraqi Freedom, unmanned ground vehicles have conducted over 30,000 missions, detecting and/or neutralizing over 15,000 improvised explosive devices (IEDs), and unmanned maritime systems have provided security to ports."

Question: Where is the recognition that UAVs (just like soldiers on the ground) have made mistakes?

There are, no doubt, UAV manufacturers who would vehemently oppose being formally linked to such development, since they might then be held (at least partially) liable for what could be deemed irresponsible actions taken by an autonomous drone or the person(s) controlling it. While this argument has some merit, it can easily be interpreted as: '*We would rather that the military controller (or, better still, no one) take responsibility for killing civilians, than to implement technology that might prevent it, and then have to accept partial blame for a failure.'* **I would argue that while, this may be in the best interest of the manufacturer in the short term, it is only because currently there is little appreciation of responsible development on the part of the military and the three branches of the U.S. federal government. To presume that such recognition will not grow is unreasonable.**

3. A Framework for Responsible UAV Development

	Technological	Behavioral	Societal	Economic	Political	Legal
Operation						
Performance						
Context						
Environment						
Uncertainty						

Table 1. Example of a template that could aid in identifying key variables related to various combinations of major factors associated with responsible development of UAVs.

4. Responsible Development in a Dynamical Systems Framework.

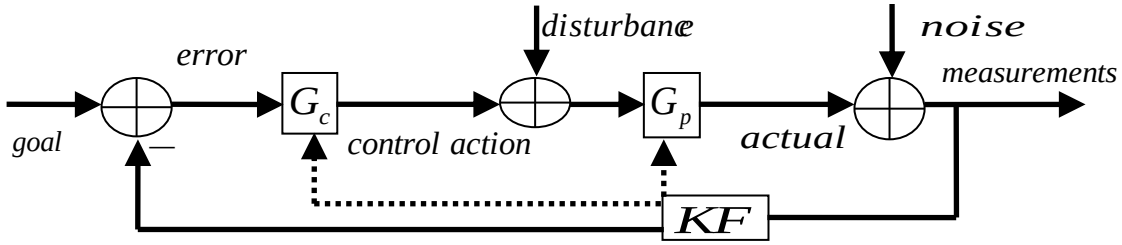

Figure 1. A simple block diagram schematic for modeling and control of input/output and state variables.

5. An Example of a Dynamical Systems Approach for Responsible UAV Use in monitoring Interstate Highway Traffic

***Main Goal*:** *To utilize a UAV to provide a safe travel environment along a specified interstate highway.*

	Technological	Behavioral	Societal	Economic	Political	Legal
Operation	1.UAV:speed, range, height 2.Vehicle: speed, type 3.Weather	1.Target pattern 2. Pattern flow 3.Recent action history 4.Controller	1.Recent news	1.Maintenanc 2.Quality Control	Public perception	FAA
Performance	1.Camera: resolution, frame rate, speed estimate	1. Noninvasive 2.Communication breakdown 2.Traffice flow 3.Traffic Density	1.Recent news	1. Court Costs 2.Legal Challenges	Public perception	Noninva-sive
Context	1. Urban vs. Rural 2. Pollution	1. Discourage speeding 2.Ground support	1.Urban vs. rural 2.Time of day	1.Burden of fines 2.Transport delays 3.Reduced toursim	1.Loss of income 2.Reduced toursim	Traffic flow
Environment	1.Weather 2.Terrain	1.Weather 2.Terrain	1.Weather 2.police-state			
Uncertainty	1.Speed 2.Poor visibility	1.Target pattern 2.Wrong vehicle	1.Favoritism		1.Favoritism	

Table 2. Variables that might be considered in relation to responsible UAV development/deployment to monitor interstate traffic.

Examples of command input state variables:

C1: A vehicle that is traveling at a speed of more than 15 mph above the limit for a duration of more than 30 seconds, or a vehicle that is exhibiting unusually erratic behavior should be cause to send out a patrol vehicle.

C2: Desired speed characteristics should include (i) no vehicle should be more that 15 miles per hour (mph) above the posted speed limit, (i) 99% of vehicles should be no more than 10 mph above, and (iii) 75% should be within 5 mph. Ideally, one might desire that all vehicles are within 5 mph of the posted limit. Even if this were possible, one should question whether or not relaxing it would pose a measurable decrease in achieving the main goal.

C3: Drivers should be aware of the potential of being monitored, but should not exhibit driving behavior that can be interpreted as being annoyed, nervous, or unduly cautious. In other words, the well-being and enjoyment of travelers who are in reasonable compliance with the speed limit and potential weather and traffic conditions should not be deprived of that state of mind.

C4: When a vehicle is targeted for fixed gaze tracking, the video information must be accompanied by uncertainty bounds that take onto account all other major variables that influence the uncertainty of the estimated speed.

C5. Surveillance should not be detrimental to tourism; especially during national holiday weekends.

C6. Actions to be taken should be mindful of the potential for litigation that might ensue as a result of excessive uncertainty in documented speed in relation to more accurate data obtained from the target vehicle's on-board data collection system.

“US Drone Crew Blamed for Civilian Deaths” Associated Press, 30 May 2010

KABUL, Afghanistan — U.S. military investigators found that "inaccurate and unprofessional" reporting by U.S. operators of a Predator drone was responsible for a missile strike that killed 23 Afghan civilians in February, according to a report released Saturday.

“Drone Pilots Could be Charged with War Crimes” www.wired.com , 28 April 2010

Loyola Law School professor David Glazier, a former Navy surface warfare officer, said the pilots operating the drones from afar could — in theory — be hauled into court in the countries where the attacks occur. That’s because the CIA’s drone pilots aren’t combatants in a legal sense

“Under Panetta a More Aggressive CIA” Washington Post 21 March 2010

Retired CIA officer Henry Crumpton, who pioneered the use of armed Predator drones in Afghanistan and was a top counterterrorism official at the State Department under Bush, said the number of strikes tells only part of the story:

"You have to know where to put the bird to begin with. It's a dynamic process. Once you have a strike, you have disruptions and you have more intelligence to collect. It's a wonderful cycle that involves all-source collection and analysis, and the Predator is only part of it."

“CIA Drone Operators Oppose Strikes as Helping al Qaeda” Inter-Press Service 3 June 2010.

Jeffrey Addicott, former legal adviser to U.S. Special Forces said CIA officers "are very upset" with the drone strike policy. Because the drone strikes kill innocent civilians and bystanders along with leaders from far away, they "infuriate the Muslim male", thus making them more willing to join the movement. The men in Pakistan's tribal region “view Americans as cowards and weasels”.

“UN Official Set to Ask U.S. to End CIA Drone Strikes” New York Times, 27 May 2010.

Philip Alston, the United Nations special rapporteur on extrajudicial, summary or arbitrary executions, said Thursday that he would deliver a report on June 3 to the United Nations Human Rights Council in Geneva declaring that the “life and death power” of drones should be entrusted to regular armed forces, not intelligence agencies.

Workshop Talks Related to Responsible Development of UAVs:

"The Challenges Awaiting Governments Over the UAV Quest" Yasar Gurbuz *et al.*

"Assessment of Expertise Development & Cognitive Workload of UAV Operators…" Murat Cakir *et al.*

"Structural Changes in Future Military Operations & Human Factors…" Coskun Kurkcu *et al.*

"Modern UAV Design & Operation…" Arsev Eraslan

This level of sophisticated integration of modeling can, and <u>should</u> be brought to bear in development of social/political/economic/legal dynamical models related to responsible UAV development.

Question: Will governments take the lead?

Answer: NO! Because governments don't have a clue as to the nature of such models.

Question: Will Industry take the lead?

Answer: Probably **NOT!** Because the short term pay-off isn't there.

Question: Will the military take the lead?

“Every gun that is made, every warship launched, every rocket fired, signifies in the final sense a theft from those who hunger and are not fed, those who are cold and are not clothed….

I hate war as only a soldier who has lived it can, only as one who has seen its brutality, its futility, its stupidity. “

Dwight D. Eisenhower