A Shift in Automation Philosophy: From Manned to Unmanned

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Talk Outline

- Emerging Importance of UAVs
- Levels of Automation
- Automation Lessons Learned
- Manned Philosophy
- Unmanned Philosophy
- Research Areas and Issues
- Trade-off Tool
- Conclusions

Emerging Importance of UAVs

- Dull, dangerous and dirty
- Safe, effective (and lethal) recon
- Extension of conventional systems
- Battlefield (just in time) delivery of blood, ammo, etc.
- Savings from procurement costs, logistics, personnel, training, operating costs
- UAVs in the National Air Space (NAS)

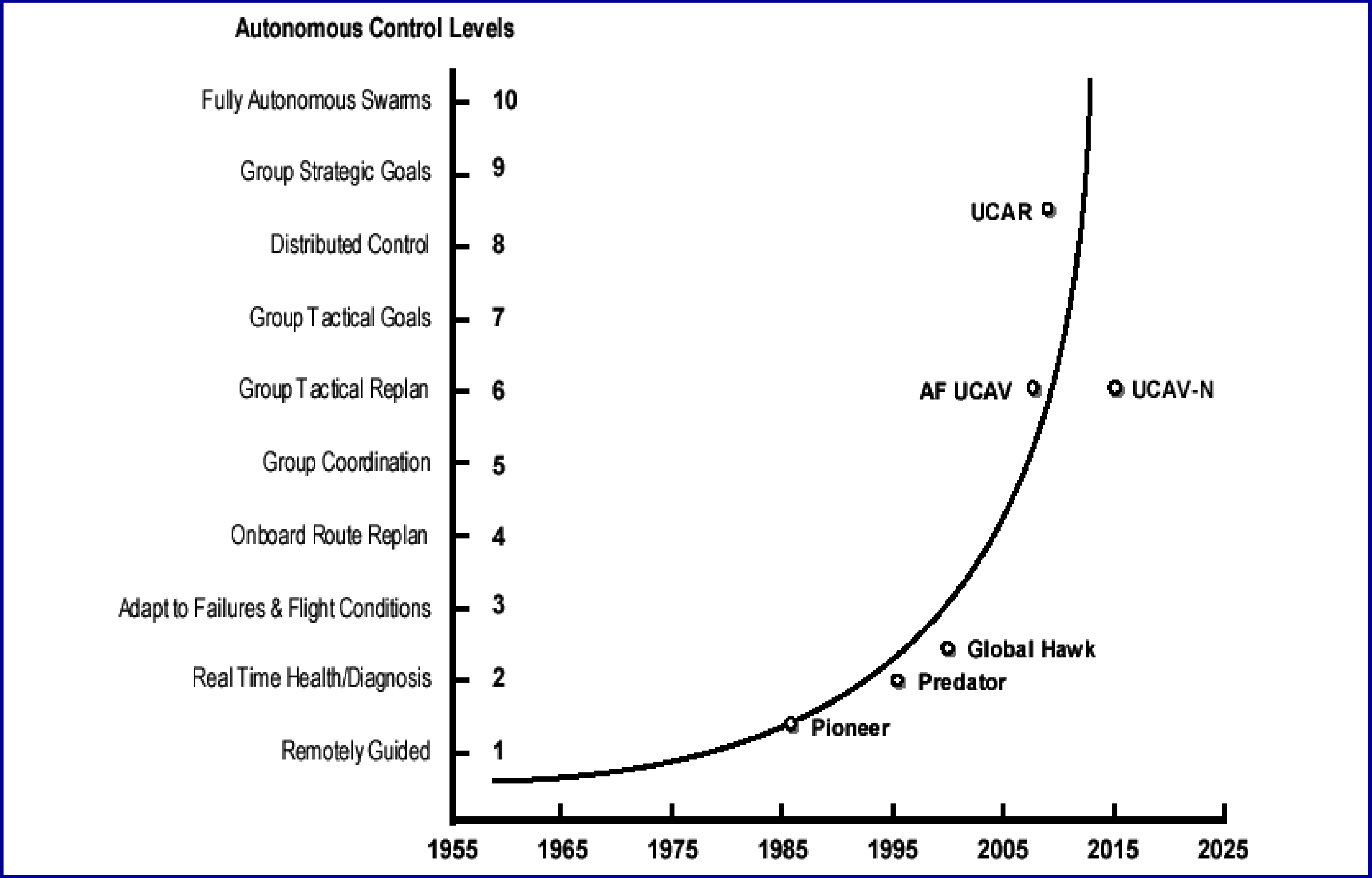
Automation Enablers

- One operator controlling multiple UAVs
- Swarming UAVs that autonomously work together to achieve mission goals
- Collaborative UAVs that modify mission goals in response to circumstances
- UAVs that locate terrorists, estimate collateral damage and eliminate the terrorists (Bright, 2002)
- *Semi-autonomous* systems in which the operator only intervenes for contingency management/ off-nominal conditions
- Autonomous collision avoidance

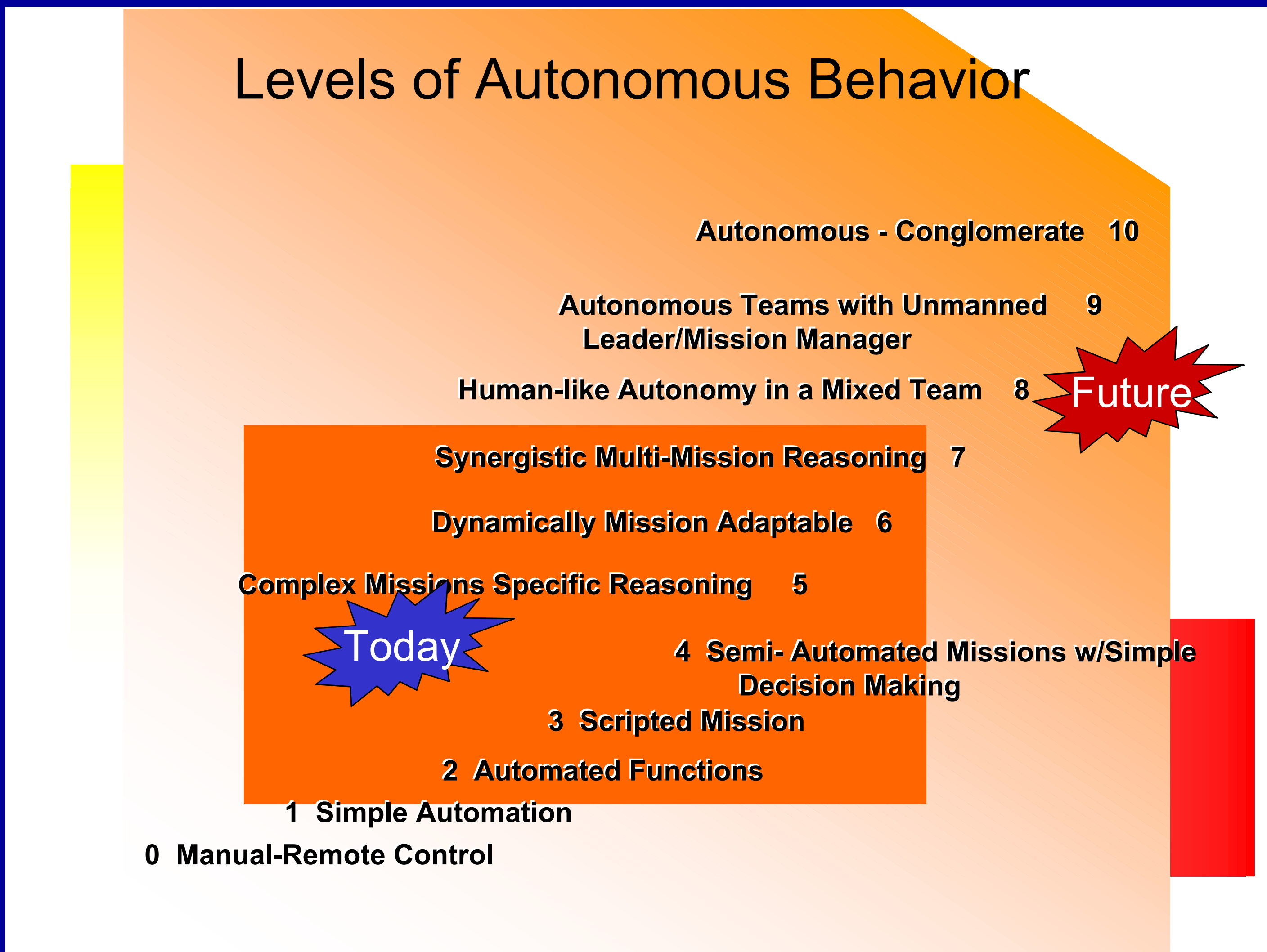
Autonomous Control Level Definition
OSD Unmanned Vehicles Roadmap (2002)

Level	Definition
10	Fully Autonomous Swarm
9	Group Strategic Goals
8	Distributed Control
7	Group Tactical Goals
6	Group Tactical Re-plan
5	Group Coordination
4	Onboard Route Re-plan
3	Adapt to Failure and Flight Conditions
2	Real Time Health/Diagnosis
1	Remotely Guided

Autonomous Control Level Trend

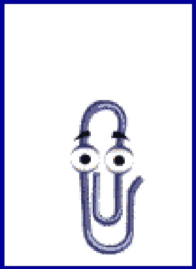


Army Science Board



What's the Problem ?
Effective Human-Automation Interaction is Difficult !

- Everyday Examples
  - VCR
    - Auto record programs
  - Computer helper
    - Paperclip
    - Auto-format
    - Spelling (hsi = his)
  - Automated voice menu



Examples from Manned Aviation: Mode Awareness (Degani, 2003)

- KAL 007
  - Pilots were in heading hold
  - Moved Mode Control Panel selector to Inertial Navigation System (INS)
  - Did NOT meet entry conditions
    - Within 7.5 miles of route
    - In general direction of route (~30 degrees)
  - INS never engaged, heading hold is less accurate and over time they drifted hundreds of miles off course

Complacency (Azar, 1998)

- 1995 Panamanian cruise ship Royal Majesty off the coast of Nantucket
- Satellite-based navigation failed
- Other sources of info were correct and available, but unmonitored
- The ship ran aground

More Examples

- Automation Bias - Tendency to utilize automated cues as a heuristic replacement for vigilant information seeking and processing (Mosier, Keyes, Bernhard, 2002)
- Accountability - Who is responsible ?
- Loss of situational awareness - out of the loop unfamiliarity (OOTLUF), Lee & Moray, 1994
- Scope of error - …while reducing small errors, computer-based systems may invite large blunders (Wiener, 1985a, 1988)
- Wiener (1989) - We find the present generation of automation essentially sound, but lacking in proper user interface design

Manned Philosophy

- Billings (1991)
  - The Human must be in command.
  - To command effectively, the human operator must be involved and informed.
  - The automated system must be predictable.
- Rotorcraft Pilots Associate (1999)
  - “Although RPA can initiate actions on contact, it always keeps the pilot in charge of the aircraft. The pilot's authority allows for acceptance or rejection of any RPA suggested action. “
- “Boeing flight decks are designed to provide automation to assist, but not replace, the flight crew member responsible for safe operation of the airplane.”

Unmanned Philosophy Shift

- Removing the pilot from the vehicle eliminates man-rating requirements, pilot systems, and interfaces.

http://www.darpa.mil/j-ucas/index.htm

- For UAV systems to reach their full potential, they have to be highly automated.
- “Execute mission automatically, Intelligent wingman, Auto mission adjust”

The Army’s Future UAV Force, Cerny, 2001

- Shift from Human in command to human gives the UAV its “proxy” for full autonomy.

Clough, 2002

Why the Perception of Shift ?

- Numerous briefs that stress autonomy and don’t mention human interaction
- To fly in commercial airspace, we must automate as much as possible
  - Aircraft manufacturer
- We can reduce the fatal accident rate of general aviation, if we can automate enough
  - Former regulatory official

Philosophy is Not Necessarily Explicit

- Association for Unmanned Vehicle Systems International (AUVSI) Title Frequency Search
- 2003
  - – 12 Instances of Autonomy/Autonomous
  - – 0 Instances of Human/Operator
    - 1 Humanoid, 1 Humanitarian
- 2002
  - – 13 Instances of Autonomy/Autonomous
  - – 3 Instances of Human/ Operator

Not all automation is bad or badly implemented

- Examples of Successful Automation
  - VCR - TiVo
  - Commercial Airline Crew Reduction
  - Anti-lock brakes
  - F-16 Flight Controls
- Successes tend to be skill-based and sometimes rule-based behaviors
  - Knowledge-based behaviors are more difficult to automate and more difficult to interface to the human
  - Knowledge-based behaviors are defined as those controlled by the highest level of cognitive processing hierarchy and rely on a mental model of the system (Rasmussen, 1983)
- Not all UAV designs or functions are following this trend:
  - Weapons release

Philosophical Shift Concerns

- But, automation comes with risk:
  - Poor human-system interaction, leading to poor performance
  - High operator workload, low situational awareness
- Risk is elevated with automation of knowledge-based behaviors:
  - Group Tactical Goals
  - Distributed Control
  - Group Strategic Goals
  - Fully Autonomous Swarm
  - “Human-like” Autonomy

Research Areas & Issues

- Guidelines specific to Human-Automation Interaction for UAVs
- Requirements driven function allocation. Don’t automate just because you can. HF has to push back. (The designers/ program managers aren’t going to.)
- UAV Human-Automation lessons learned database
- Optimal automation levels for mission context, workload and automation transitions
- Adaptive automation levels based on workload, physiological indices
- Measures of “goodness” of human-automation interfaces

Cost/ Benefit Trade-off Analysis Tool for UAV Automation

- Analysis of trade-offs among:
  - Probability of mission success
  - Level of UAV automation
  - Context/Mission/Platform
  - Operator workload/ situational awareness

Notional Tool Example

- Inputs
  - Context/Mission Platform
    - Recon of large area
    - Apache teamed with three UAVs (Shadows)
  - Level of automation
    - Vary from 5 (complex mission specific reasoning) to 9 (Autonomous team w/ unmanned leader)
    - Contingency Management
      - Lost link (to one or more)
      - Equipment failures (of one or more)
- Outputs
  - Workload and Situational Awareness
    - Co-pilot gunner
    - Ground station operator
  - Probability of mission success

Conclusions

- There is a philosophy shift from manned to unmanned aircraft
- UAV industry must take advantage of lessons learned
- Perception that high levels of automation are necessary for UAV systems to reach full potential
- Automation comes with risk, especially for knowledge based behaviors
- Need guidelines for UAV Human-Automation interaction
- Need for research to populate a trade-off tool