Autonomous Systems Complexity Assessment
Day 1 Intro Workshop

Facilitator: Eric Smith, UTEP Professor

Assistant: William Hale, NMT Student

Participants:

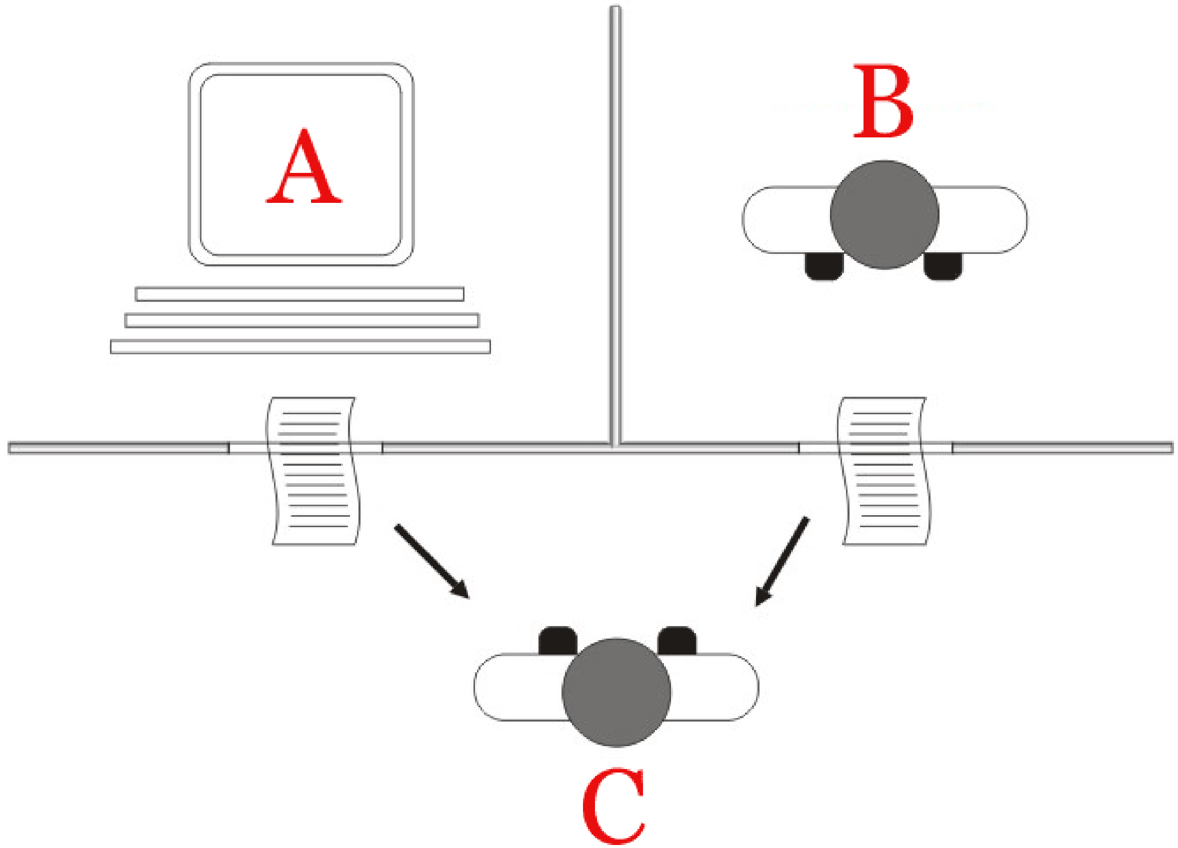
• Griselda Acosta	UTEP Student
• Randy Anway	New Tapestry, LLC
• John Brtis	MITRE Corp
• Sergio De La Rosa	UTEP Student
• Jim Larkin	MEI Technologies, AFRL Contractor
• Ron Lyells	Retired Honeywell
• Tim Marks	Sandia National Labs
• Tim Wiseley	Sandia National Labs

R1: Doctoral University:
Very High Research Activity

Autonomous Systems Complexity Assessment

Eric Smith

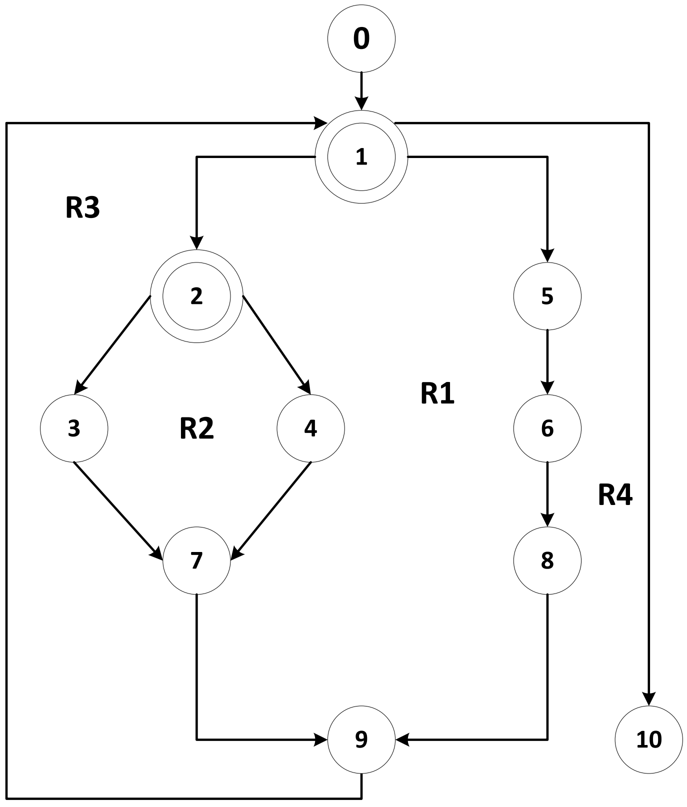
Turing Test



- Alan Turing 1950
- machine's ability to exhibit human-like intelligent behavior
- natural language conversations

Cyclomatic Complexity

(McCabe, 1976)



- CC = E – N + 2P
- **C** = # Edges – # Nodes + 2(Components)
- **C** = 13 edges – 11 nodes + 2 = 4
- Path 1: 0-1-10
- Path 2: 0-1-5-6-8-9-1-10
- Path 3: 0-1-2-4-7-9-1-10
- Path 4: 0-1-2-3-7-9-1-10

8 Strategies

Helle, Strobel & Schamai, Testing of Autonomous Systems,
26th INCOSE Symposium, 2016

- Knowledge (Wirsing, Hölzl, Koch, & Mayer, 2011)
- Adaptation
- Self-Awareness
- Emergence

- Complex Environment, Complex Software, Non-deterministic Behavior
- System Trust; Operational Trust
- Fault Avoidance; Fault Removal; Fault Tolerance

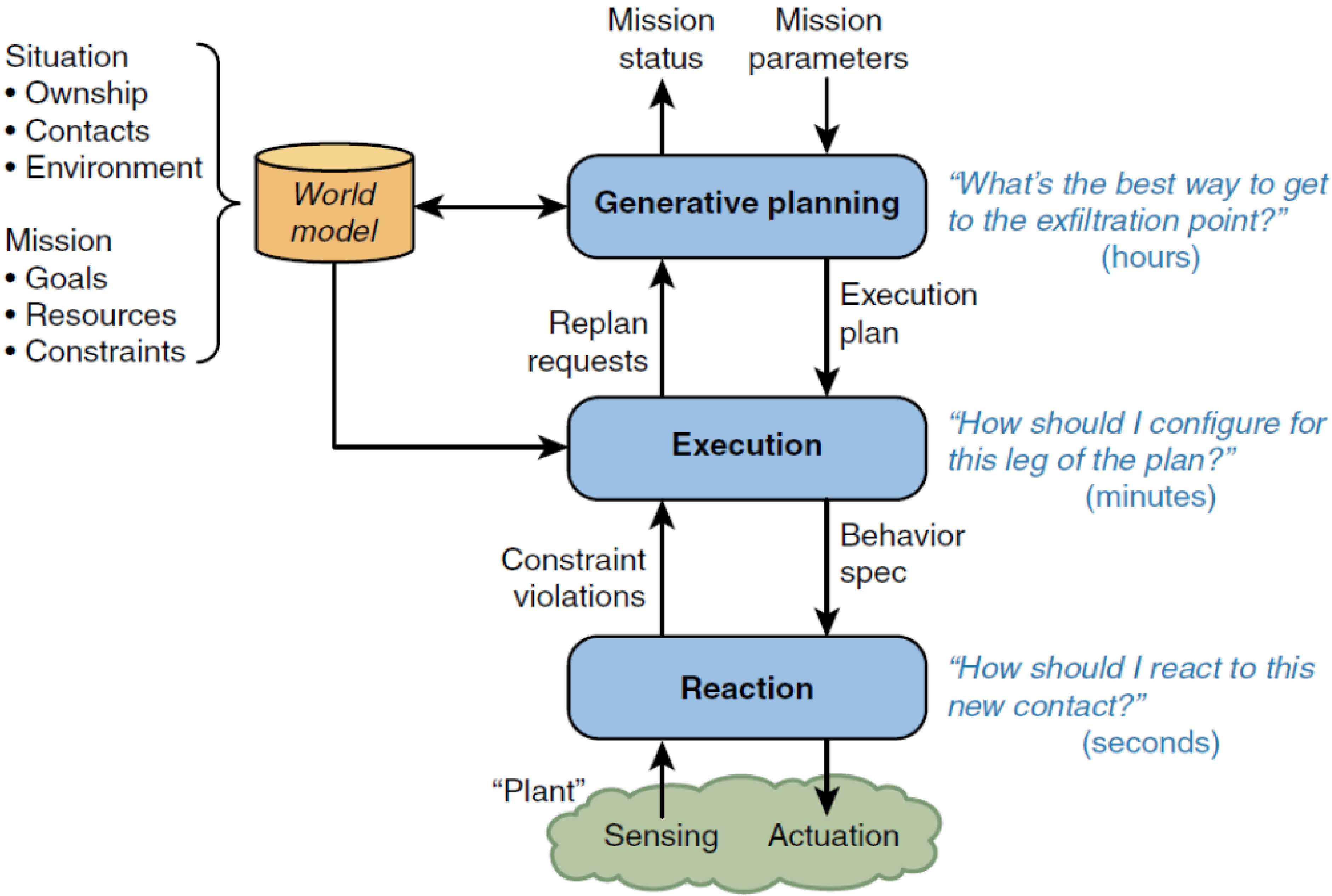


Figure 1. Layered Autonomy Model (Watson & Scheidt, 2005)

8 Strategies

Helle, Strobel & Schamai, Testing of Autonomous Systems,
26th INCOSE Symposium, 2016

1. Use **Models**
2. Be **Formal**
3. **Automate**
4. Test **Early**
5. Test **Continually**
6. Test **Virtually**
7. Test the **Correctness of the Autonomy Capability**
8. Think **Ahead**

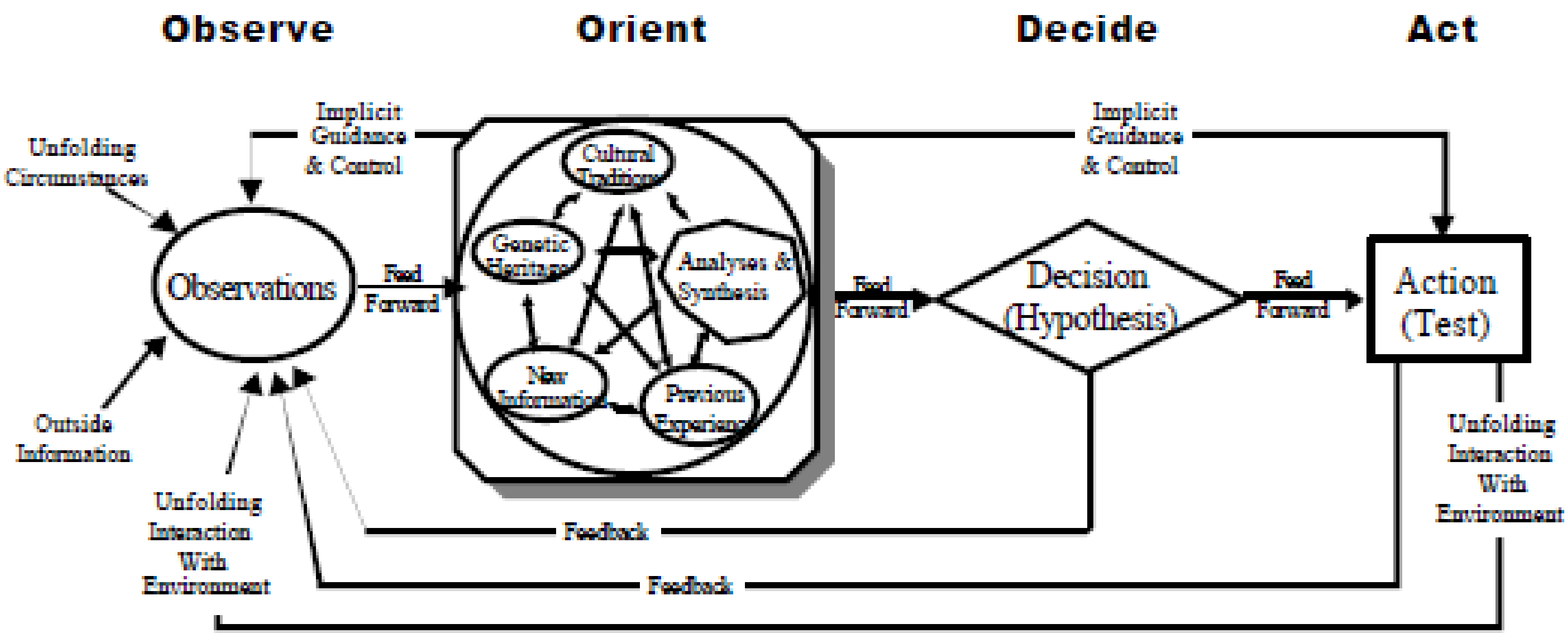
SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver **monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system **("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

1)	The computer offers no assistance, human must do it all.
2)	The computer offers a complete set of action alternatives, and
3)	narrows the selection down to a few, or
4)	suggests one, 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 the human, or
8)	informs him after execution only if he asks, or
9)	informs him after execution if it, the computer, decides to.
10)	The computer decides everything and acts autonomously, ignoring the human.

Table 1. Sheridan's scale of degrees of automation [5]

Boyd's OODA "Loop"

Sketch



Note how orientation shapes observation, shapes decision, shapes action, and in turn is shaped by the feedback and other phenomena coming into our sensing or observing window.

Also note how the entire "loop" (not just orientation) is an ongoing many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection.

From "The Essence of Winning and Losing," John R. Boyd, January 1996.

Defense and the National Interest, http://www.d-n-i.net, 2001

Level	Observe	Orient	Decide	Act
8	The computer gathers, filters, and prioritizes data without displaying any information to the human.	The computer predicts, interprets, and integrates data into a result which is not displayed to the human.	The computer performs ranking tasks. The computer performs final ranking, but does not display results to the human.	Computer executes automatically and does not allow any human interaction.
7	The computer gathers, filters, and prioritizes data without displaying any information to the human. Though, a "program functioning" flag is displayed.	The computer anlayzes, predicts, interprets, and integrates data into a result which is only displayed to the human if result fits programmed context (context dependant summaries).	The computer performs ranking tasks. The computer performs final ranking and displays a reduced set of ranked options without displaying "why" decisions were made to the human.	Computer executes automatically and only informs the human if required by context. It allows for override ability after execution. Human is shadow for contingencies.
6	The computer gathers, filters, and prioritizes information displayed to the human.	The computer overlays predictions with analysis and interprets the data. The human is shown all results.	The computer performs ranking tasks and displays a reduced set of ranked options while displaying "why" decisions were made to the human.	Computer executes automatically, informs the human, and allows for override ability after execution. Human is shadow for contingencies.
5	The computer is responsible for gathering the information for the human, but it only displays non-prioritized, filtered information.	The computer overlays predictions with analysis and interprets the data. The human shadows the interpretation for contingencies.	The computer performs ranking tasks. All results, including "why" decisions were made, are displayed to the human.	Computer allows the human a context-dependant restricted time to veto before execution. Human shadows for contingencies.
4	The computer is responsible for gathering the information for the human and for displaying all information, but it highlights the non-prioritized, relevant information for the user.	The computer analyzes the data and makes predictions, though the human is responsible for interpretation of the data.	Both human and computer perform ranking tasks, the results from the computer are considered prime.	Computer allows the human a pre-programmed restricted time to veto before execution. Human shadows for contingencies.
3	The computer is responsible for gathering and displaying unfiltered, unprioritized information for the human. The human still is the prime monitor for all information.	Computer is the prime source of analysis and predictions, with human shadow for contingencies. The human is responsible for interpretation of the data.	Both human and computer perform ranking tasks, the results from the human are considered prime.	Computer executes decision after human approval. Human shadows for contingencies.
2	Human is the prime source for gathering and monitoring all data, with computer shadow for emergencies.	Human is the prime source of analysis and predictions, with computer shadow for contingencies. The human is responsible for interpretation of the data.	The human performs all ranking tasks, but the computer can be used as a tool for assistance.	Human is the prime source of execution, with computer shadow for contingencies.
1	Human is the only source for gathering and monitoring (defined as filtering, prioritizing and understanding) all data.	Human is responsible for analyzing all data, making predictions, and interpretation of the data.	The computer does not assist in or perform ranking tasks. Human must do it all.	Human alone can execute decision.

Table 2. Level of Autonomy Assessment Scale

4	The computer is responsible for gathering the information for the human and for displaying all information, but it highlights the non-prioritized, relevant information for the user.	The computer analyzes the data and makes predictions, though the human is responsible for interpretation of the data.	Both human and computer perform ranking tasks, the results from the computer are considered prime.	Computer allows the human a pre-programmed restricted time to veto before execution. Human shadows for contingencies.
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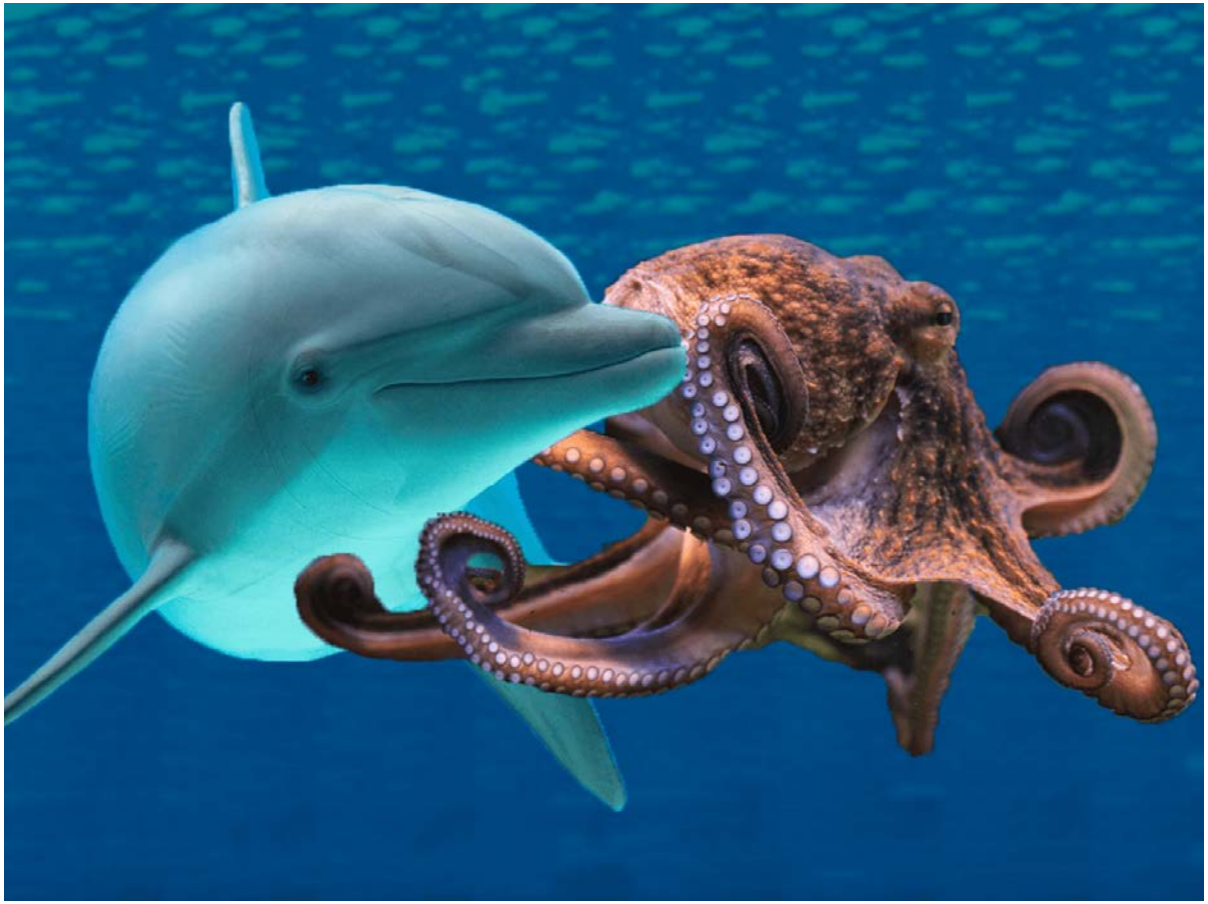
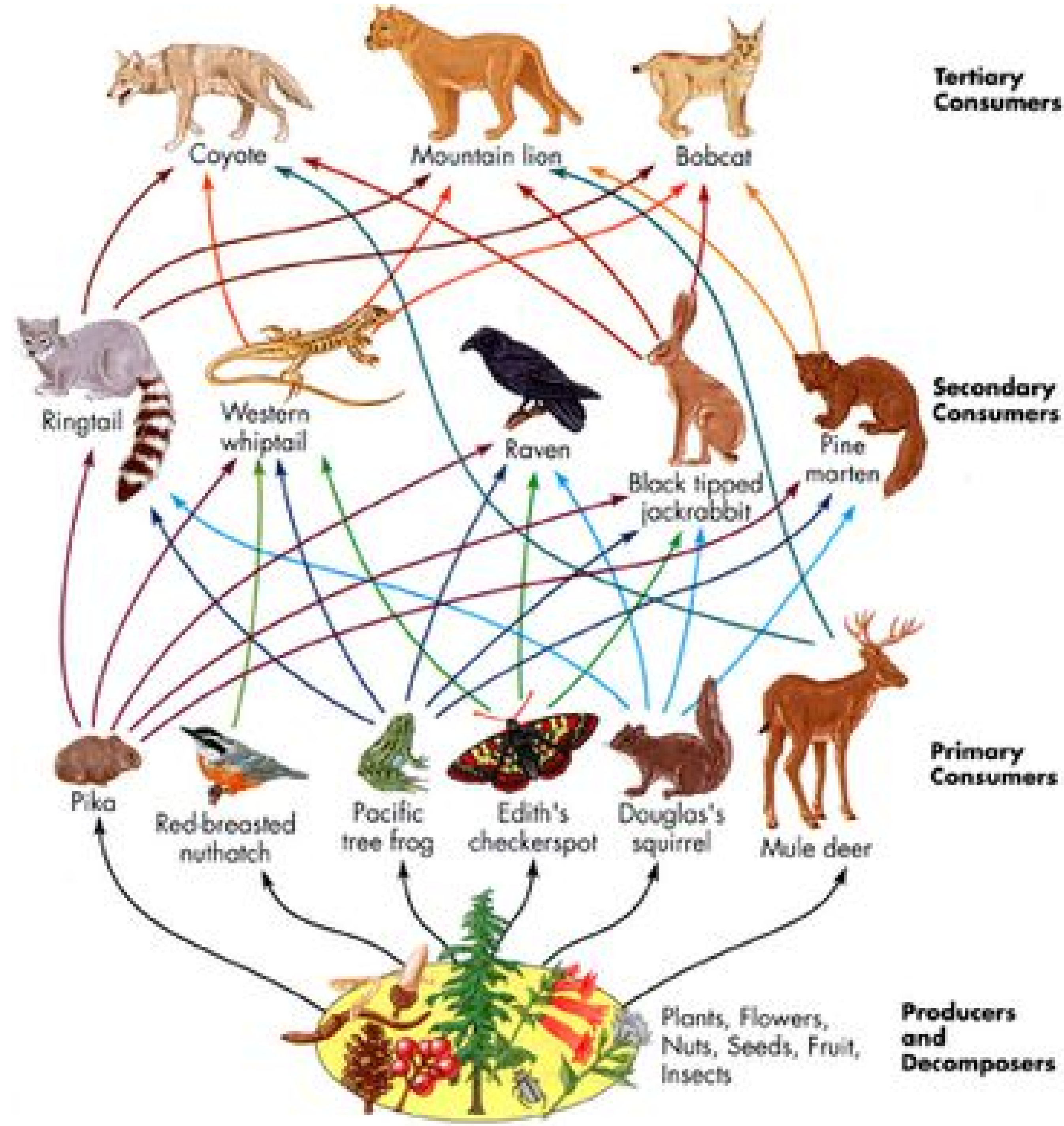
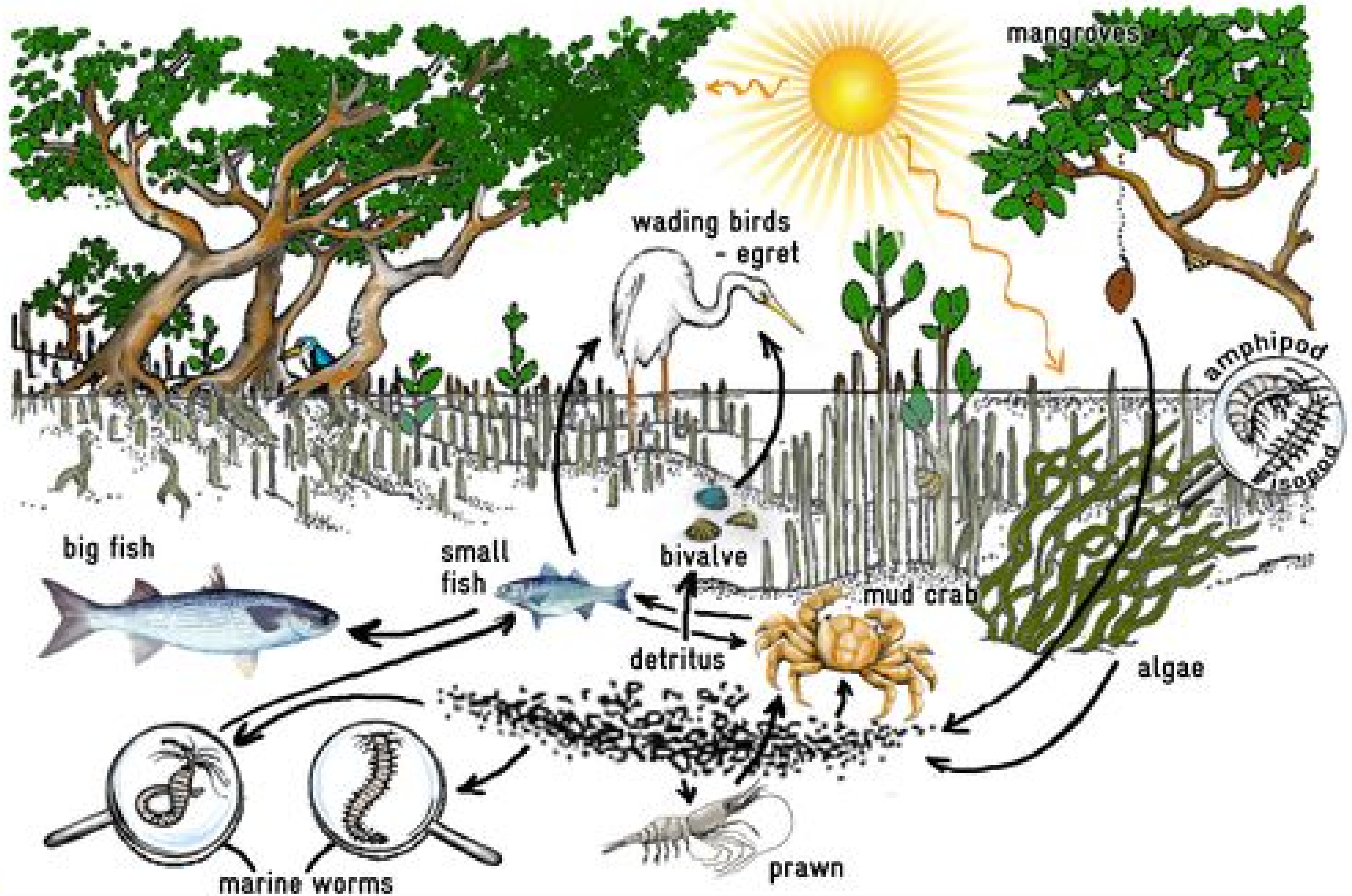
Bio-Mimicry

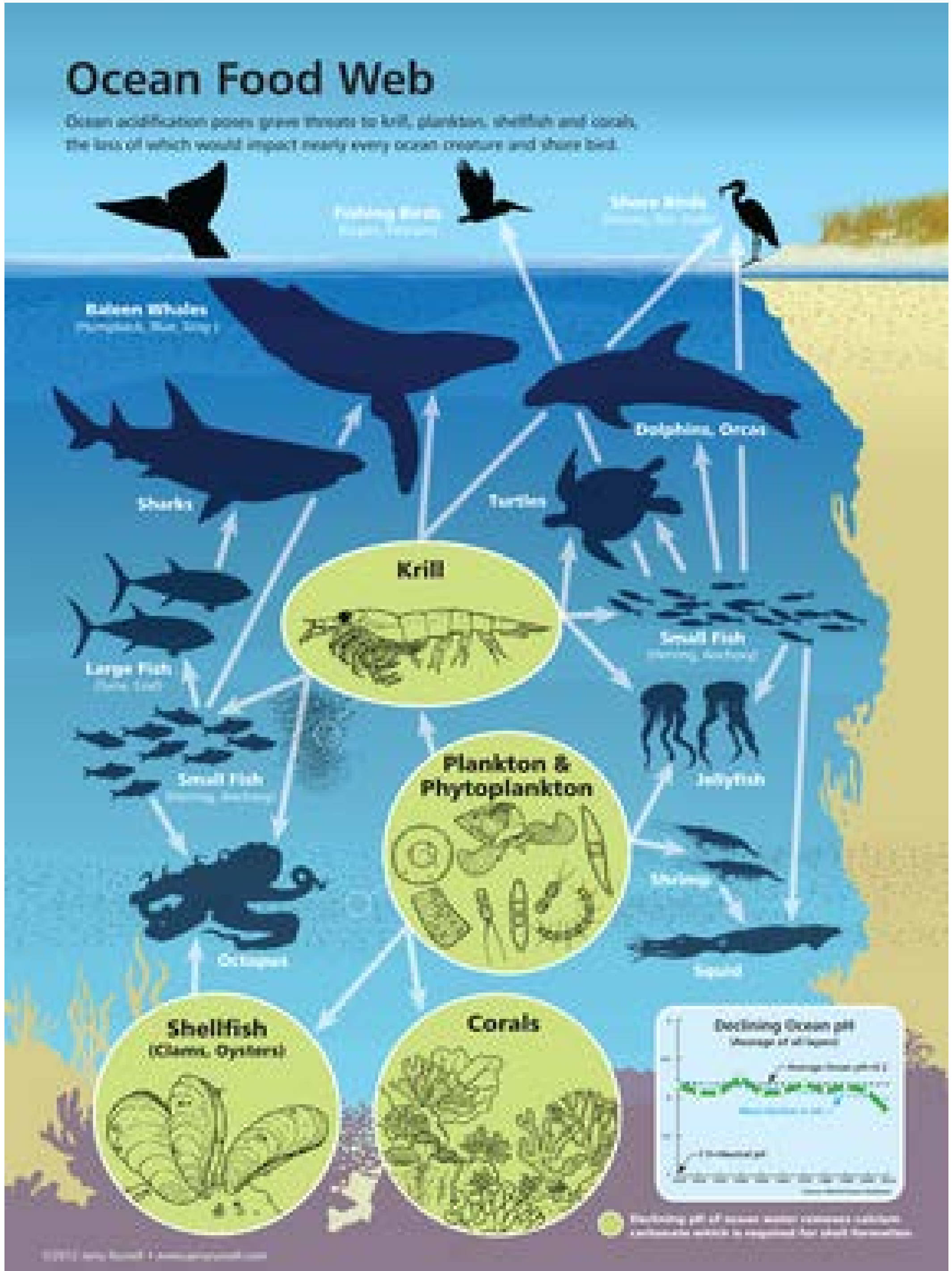




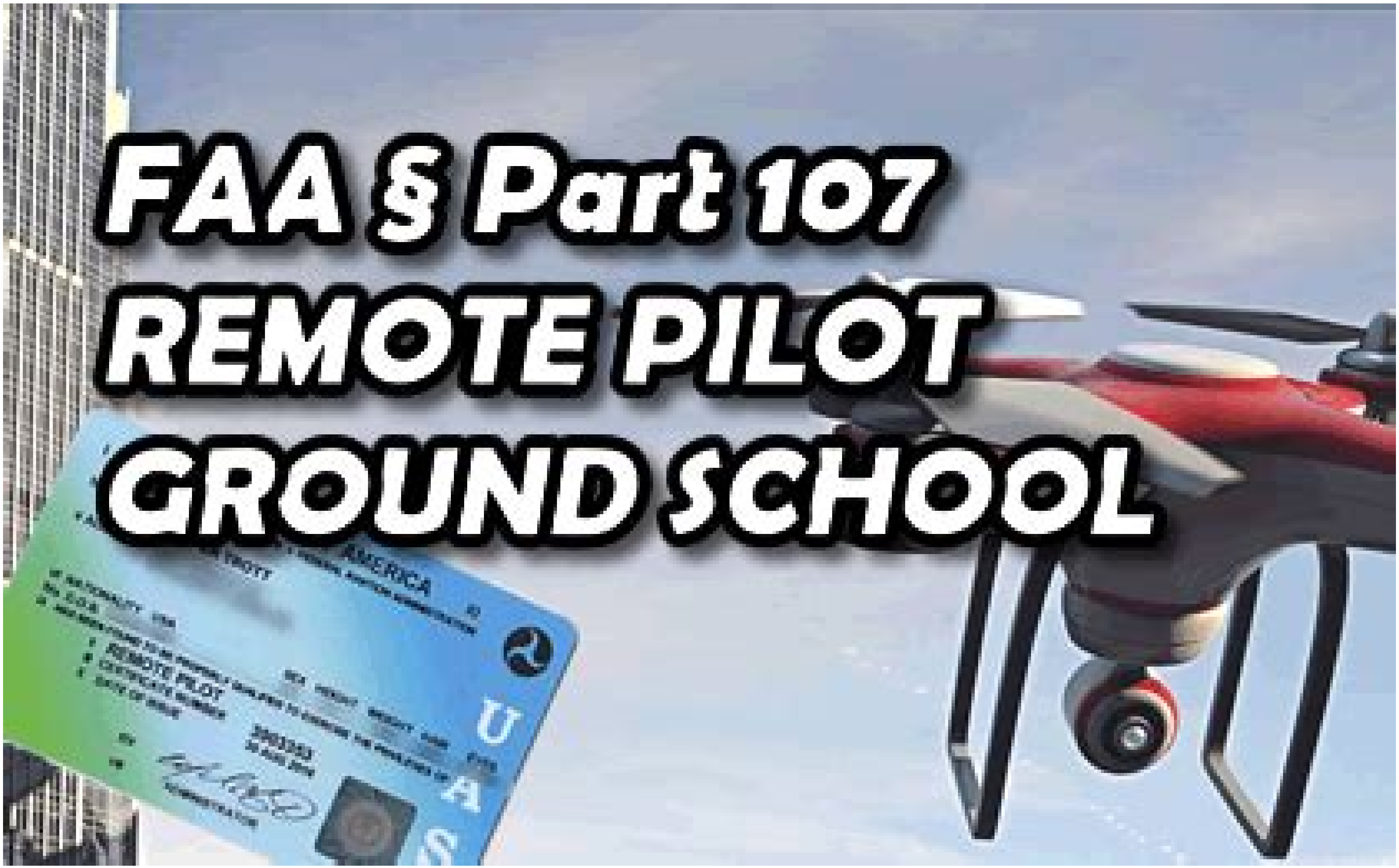
Tertiary Consumers
Coyote
Mountain lion
Bobcat
Secondary Consumers
Ringtail
Western whiptail
Raven
Black tipped jackrabbit
Pine marten
Primary Consumers
Pika
Red-breasted nuthatch
Pacific tree frog
Edith's checkerspot
Douglas's squirrel
Mule deer
Plants, Flowers, Nuts, Seeds, Fruit, Insects
Producers and Decomposers



food web - mangrove ecosystem


Ocean Food Web
Ocean acidification poses grave threats to krill, plankton, shellfish and corals, the loss of which would impact nearly every ocean creature and shore bird.
Fishing Birds
Shore Birds
Baleen Whales
Dolphins, Orcas
Sharks
Turtles
Krill
Small Fish
Large Fish
Small Fish
Jellyfish
Plankton &
Phytoplankton
Shrimp
Octopus
Squid
Shellfish
(Clams, Oysters)
Corals
Declining Ocean pH

FAA Regulation of Drones



107.51(a) (b) OPERATING LIMITATIONS – Speed and Altitude

FDA Regulation of Medical Devices

WAYMO by Google

CA DMV Autonomous Vehicle Testing Permits

- Volkswagen Group of America
- Mercedes Benz
- Waymo LLC
- Delphi Automotive
- Tesla Motors
- Bosch
- Nissan
- GM Cruise LLC
- BMW
- Honda
- Ford
- Zoox, Inc.

- Zoox, Inc.
- Drive.ai, Inc.
- Faraday & Future Inc.
- Baidu USA LLC
- Valeo North America, Inc.
- NIO USA, Inc.
- Telenav, Inc.
- NVIDIA Corporation
- AutoX Technologies Inc
- Subaru
- Udacity, Inc
- Navya Inc.
- Renovo.auto
- PlusAi Inc
- Nuro, Inc
- CarOne LLC
- Apple Inc.
- Pony.AI
- TuSimple
- Jingchi Corp

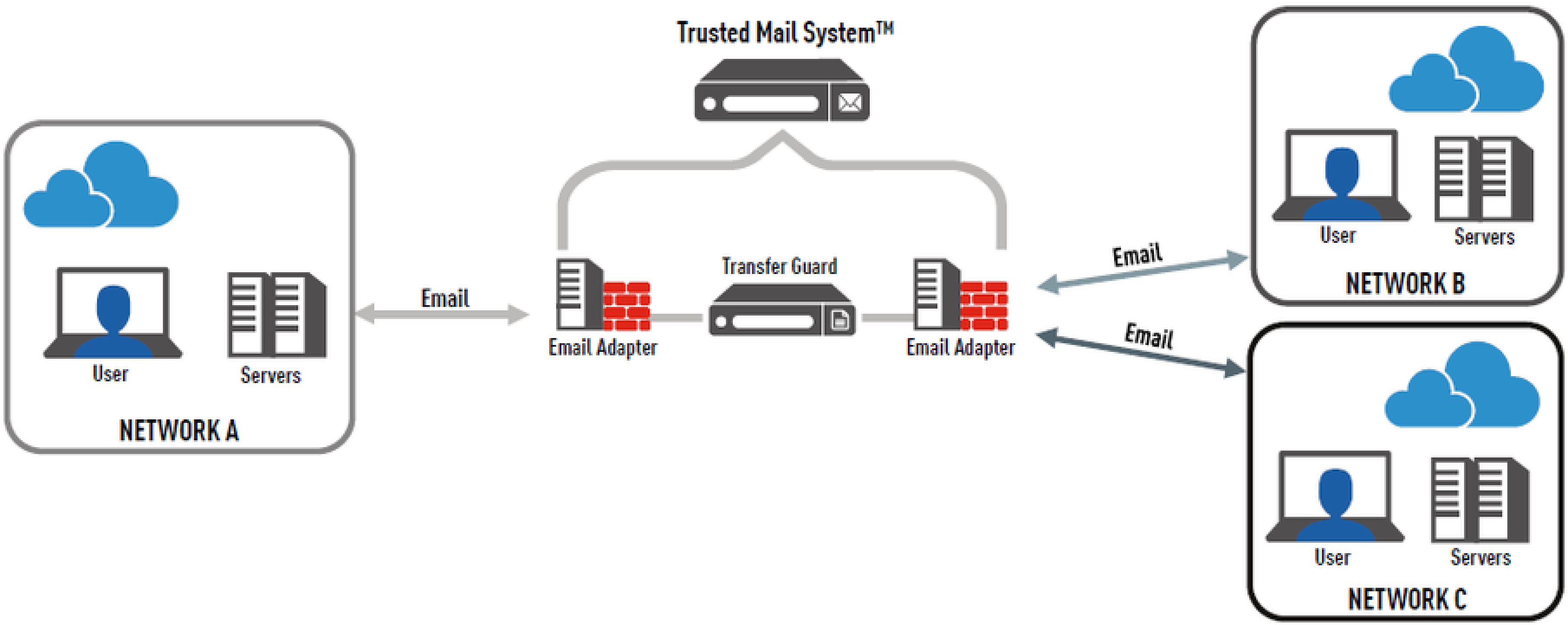
- SAIC Innovation Center, LLC
- Almotive Inc
- Aurora Innovation
- Nullmax
- Samsung Electronics
- Continental Automotive Systems Inc
- Voyage
- CYNGN, Inc
- Roadstar.Ai
- Changan Automobile
- Lyft, Inc.
- Phantom AI
- Qualcomm Technologies, Inc.
- SF Motors Inc.

- Toyota Research Institute
- Apex.AI
- Intel Corp
- Ambarella Corporation
- Gatik AI. Inc.
- DiDi Research America LLC
- TORC Robotics Inc
- Boxbot Inc
- EasyMile
- Mando America Corporation
- Xmotors.ai, Inc.
- Imagry Inc.
- Ridecell Inc.
- AAA NCNU
- ThorDrive Inc
- Helm.AI Inc
- Argo AI, LLC

CA DMV Autonomous Vehicle Testing Permits

- Vehicle Code Section 38750:
- CA department will not wait for the federal government sets autonomous technology safety standards.
- CA DMV department is relying on certifications that vehicles meet existing vehicle safety standards and certifications that the vehicles will operate safely on public roads by complying with traffic rules and regulations.
- The manufacturer must also provide a summary of test methods used to validate the performance of the vehicles and certify that the manufacturer is satisfied, based on the results of that testing, that the vehicles are safe for deployment on public roads.

Trust



Trusted Mail System™
Email
Transfer Guard
Email Adapter
Email Adapter
Email
Email
User
Servers
NETWORK A
User
Servers
NETWORK B
User
Servers
NETWORK C

Zip Line delivery

DRIVERLESS
CARS
BREAKERS
YARD
THAT'S
ALL
FOLKS
HEATH

Autonomous Systems Complexity Assessment
Reception Poster

Need

- Future development of services and integration into society
- Autonomous, systems, that includes systems of systems, tend to complex, we need a methodology to address systems complexity to ensure the development of successful autonomous systems
- Need to familiarize with new systems possibilities

Stake holders

- Systems Engineers; Government and State regulatory agencies; Businesses; Ecologist; Ethicists; Philosophers

Issues

- Relative complexity of autonomous systems and complexity of interacting with environment
- Complexity of interacting systems on various levels
- Unpredicted or uncertain untested scenarios in emergent systems.
- Systems competition with humans
- Intention and attention with respect to behavior
- Autonomous systems add digital and process logic complexity
- Nonlinear causation
- Ethics and moral code ; Paradigm shift
- No regulatory structure to govern autonomous system testing and behavior
- Environmental Economical and societal testing
- Malicious attacks, security and countermeasures
- Unattended system of systems

Autonomous Systems Complexity Assessment
Day 2 Workshop Results

Day 2 Participants:

• Randy Anway	New Tapestry, LLC
• Aly El-Osery	NMT Professor
• Jim Larkin	MEI Technologies, AFRL Contractor
• Kerry Luney	Thales Australia
• Eric Smith	UTEP professor

Autonomous Systems Complexity Assessment

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- Malicious attacks, security and countermeasures
- unintended creation system of systems

Impediments to adoption of autonomous systems

- Existing system paradigm
  - Current practices challenged
    - Theory of Warfare
  - Shared ownership
  - Infrastructure
    - Balance and investment in supporting infrastructure
  - System as a service vs. retail
- Complexity Adoption
  - Perceptual concerns
  - Perception of risk and uncertainty
  - Self learning unboundedness
  - Adoption curve and technical readiness
  - Unintended consequences of system of systems
- Government
  - Policy
  - Acquisition frame works
  - Political considerations
- Legal and insurance
  - Regulations and standards
  - Ramifications for unintended consequences
  - Accountability
  - privacy protection
- Culture
  - Social Contract
  - Religion
  - PATH
  - Education
  - Value systems

Consensus requirements

- Assumed to agreed definition of autonomy
- Process replaced by Autonomy as the initial adoption
- Must have an agreed architecture
  - Inclusive of interdependencies and environment
  - Inclusive of interoperability where applicable
- Must have an agreed level of human involvement
  - Consider biomimicry
- Must have an agreed level of environmental and economical interactions
- Must agree upon a risk profile
  - Consensus on the risk involved
  - Consensus on risk reduction strategies
- Consensus of the unintended consequences of a fault – resilience
- Change management strategies must be defined

Collaboration actions

- STEAM/PATH education
- Scenario and use case generation of high level relationship model across multiple nontechnical discipline
  - Consider mind mapping
- Seek INCOSE working groups
- Diversification and inclusion to be addressed