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Broadening the Autonomy Discussion

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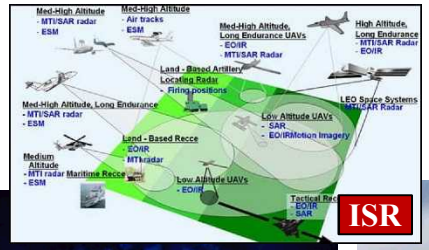
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Other Mission Areas?

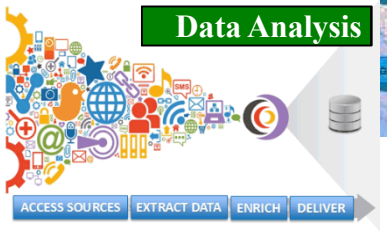
- Global security
  - Protecting the nation and the world from the most dangerous events
    - Nonproliferation, physical security, counter-terrorism
  - Reducing risk from national incidents while maintaining and facilitating trade, travel and personal freedoms
- Transportation
- Critical infrastructure
- Healthcare
  -
  -
  -

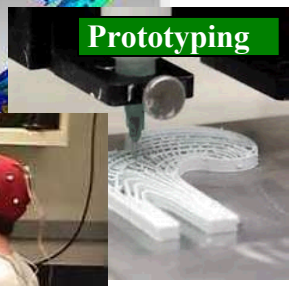
Applications

Missions



Operational Needs





Framework for Discussing Autonomy

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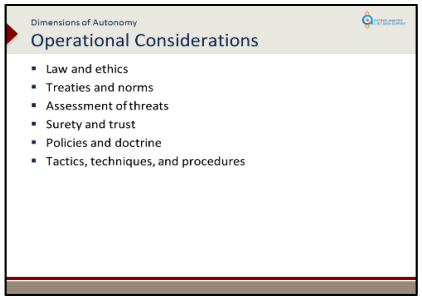
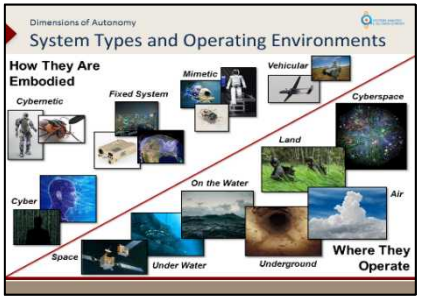
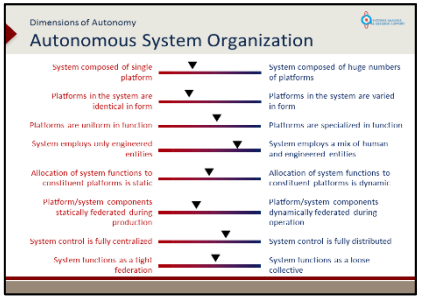
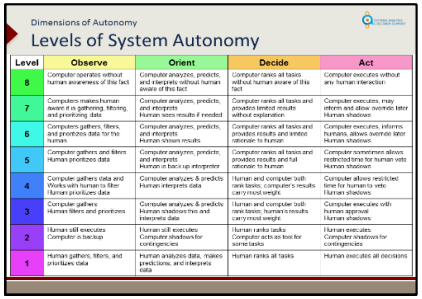
System Utilization



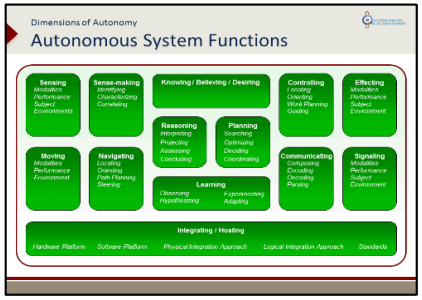
System Characteristics

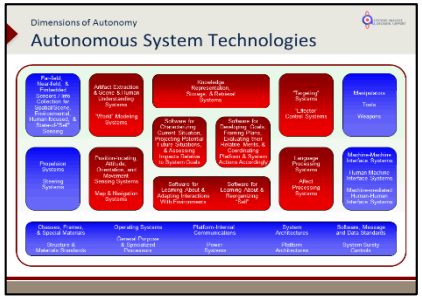




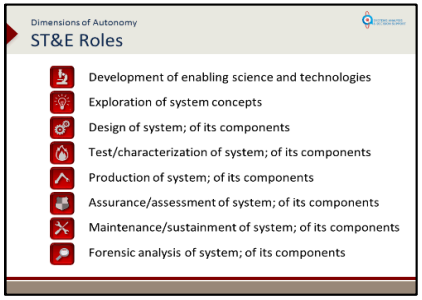


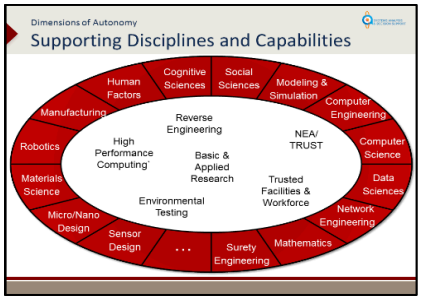
System Building Blocks





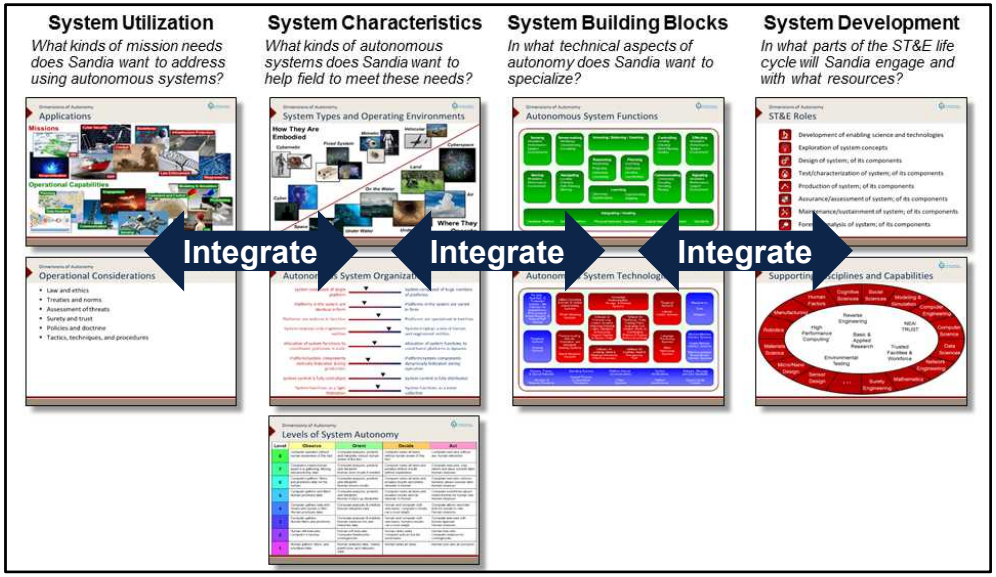
System Development





Why A Framework Matters

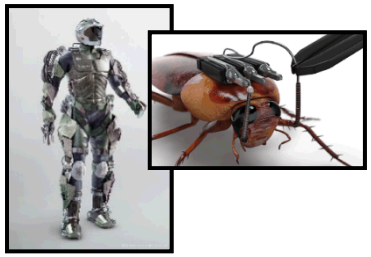
- Different stakeholders emphasize different views
- No one view is adequate to frame an robust Lab strategy
- Framework provides a means of integrating across these views



System Types and Operating Environments

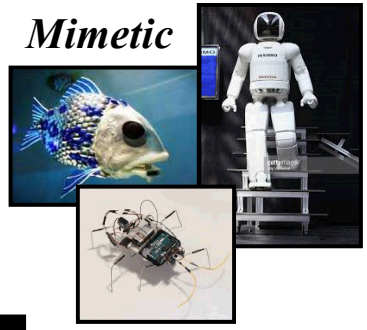
How They Are Embodied

Cybernetic



Fixed System

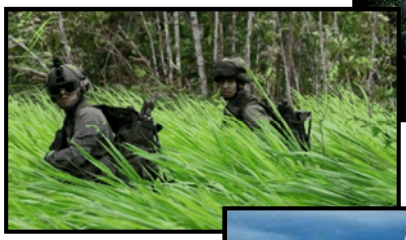
Mimetic



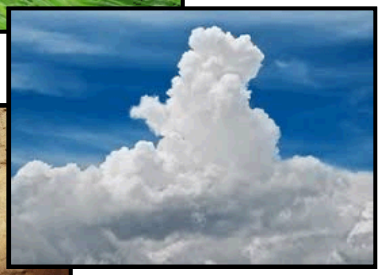
Vehicular

Cyberspace

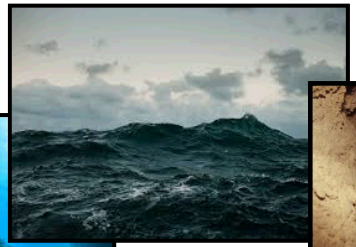
Land



Air



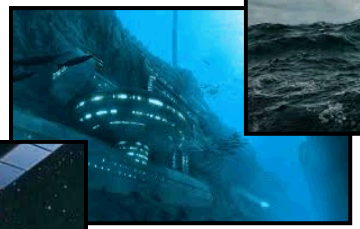
On the Water



Cyber

Space

Under Water



Underground

Where They Operate

Operational Considerations

- Law and ethics
- Treaties and norms
- Assessment of threats
- Surety and trust
- Policies and doctrine
- Tactics, techniques, and procedures

The Race for Autonomy

Pace of Autonomy Development

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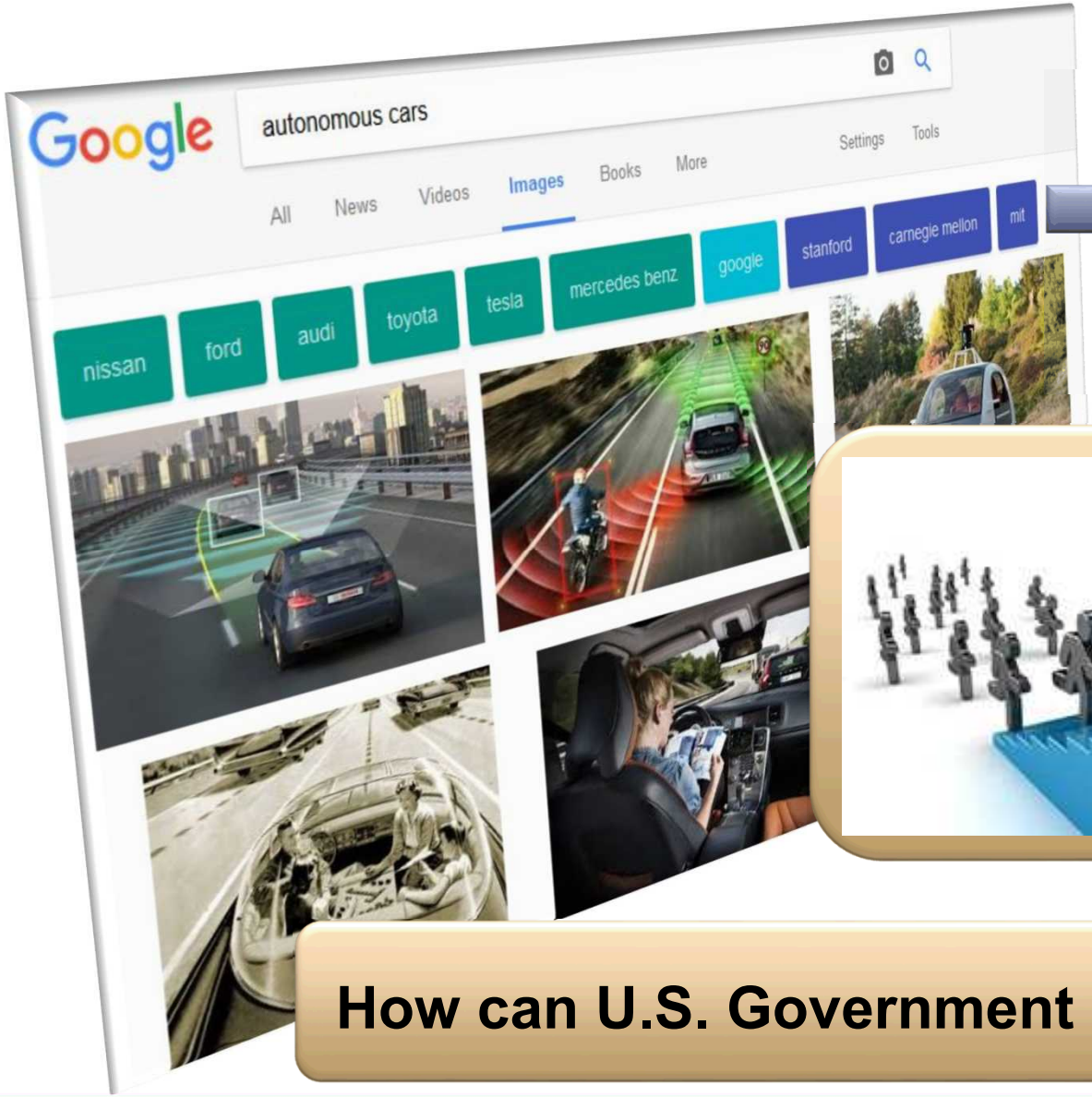

Industry Investments

How can U.S. Government keep up?

Autonomy Taxonomy

SNL Perspective

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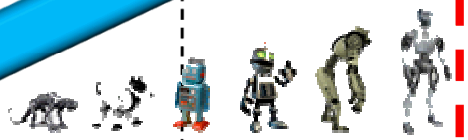
Capabilities / Complexity

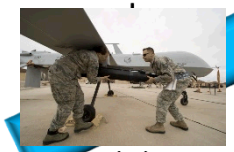
Remote Human Operation
- Slow advance
- Latent platform response
- Comms limited
- Limited SA
- Slow, less informed decision making

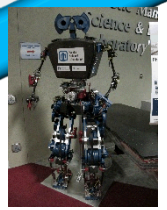
Human Guided Autonomy
- Platform level intelligence
- Constrained system response
- Comms dependent
- Improved SA
- Command intent decision making

Adaptive Heterogeneous Collectives
- Rapid, adaptive autonomy
- Comms independent
- Command intent SA
- Rapid, informed decision making

Full Trust







U.S. Values Embedded in the Machine

Privacy
Trust
Safety
Security

Potential for Technology to violate US Values

Adversaries will "Cross the Line"

Tele-Operate | **Human in Loop** | **Human on Loop** | **Human Directed**

Dull, Dirty Dangerous (3Ds)

3Ds + Difficult Time limited (4Ds)

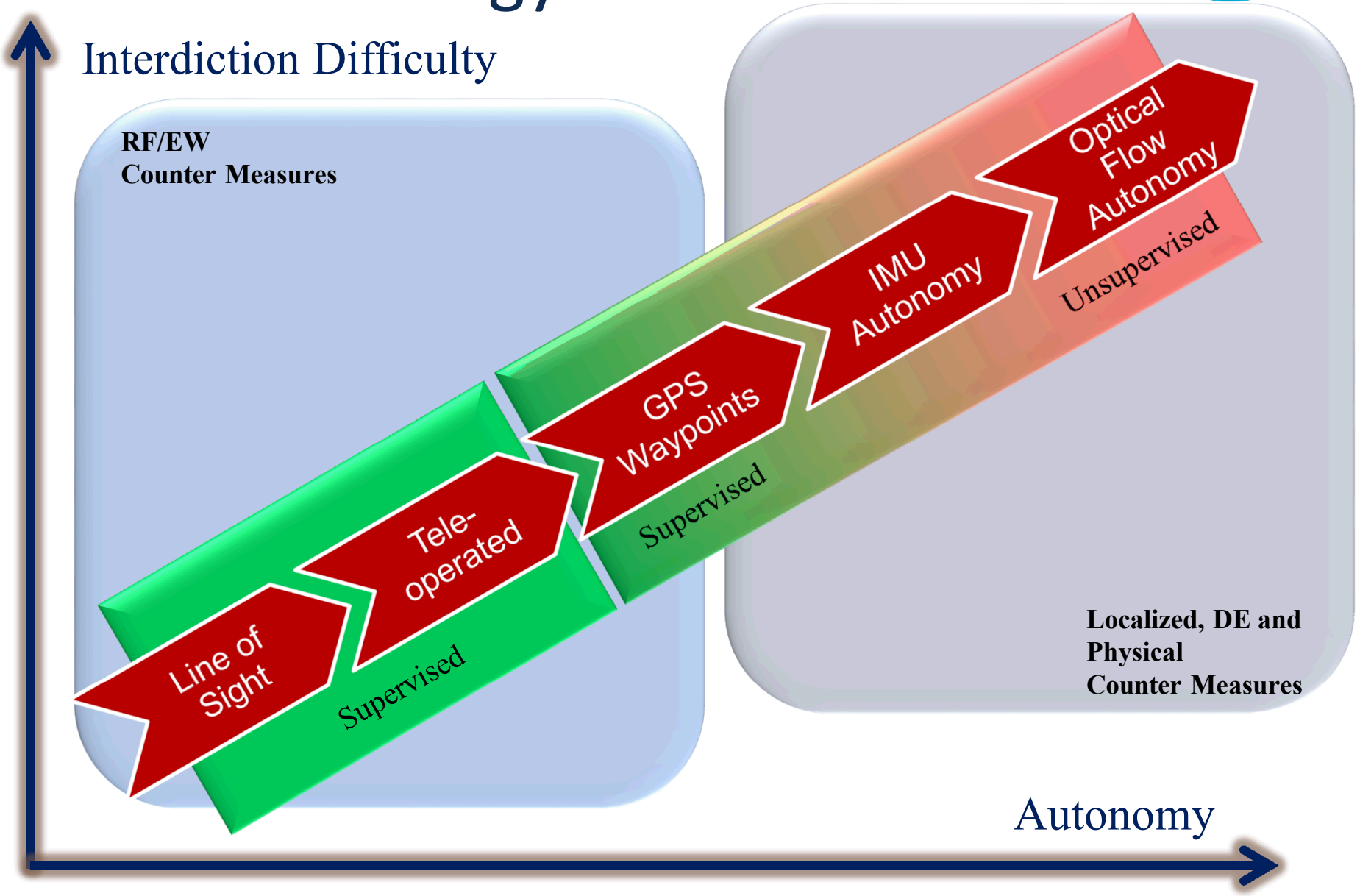
4Ds + Rapid Interactions (machine speed)

Conflicted Objectives and Environments (A2/DA)

Nature of Tasking

Technical Challenges

UAS Technology Evolution



Autonomy Challenges

Unintended Consequences

Impact of Autonomy on Employment

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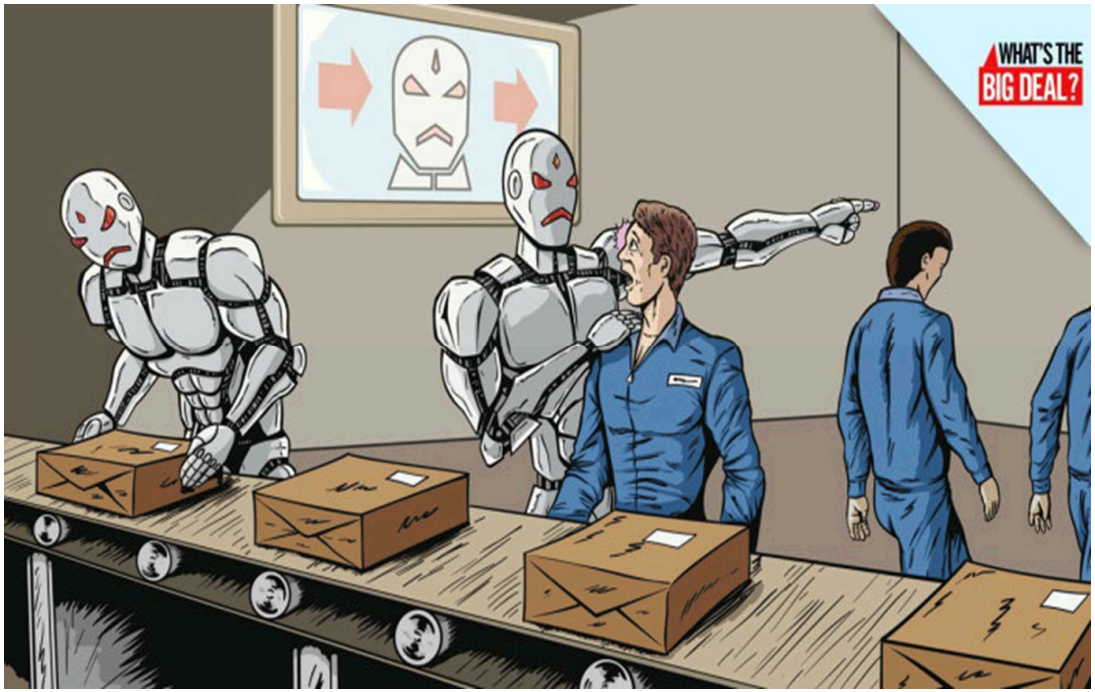
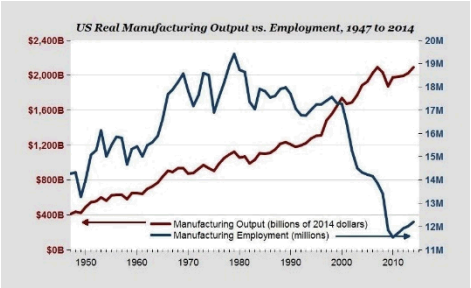




WORLD ECONOMIC FORUM

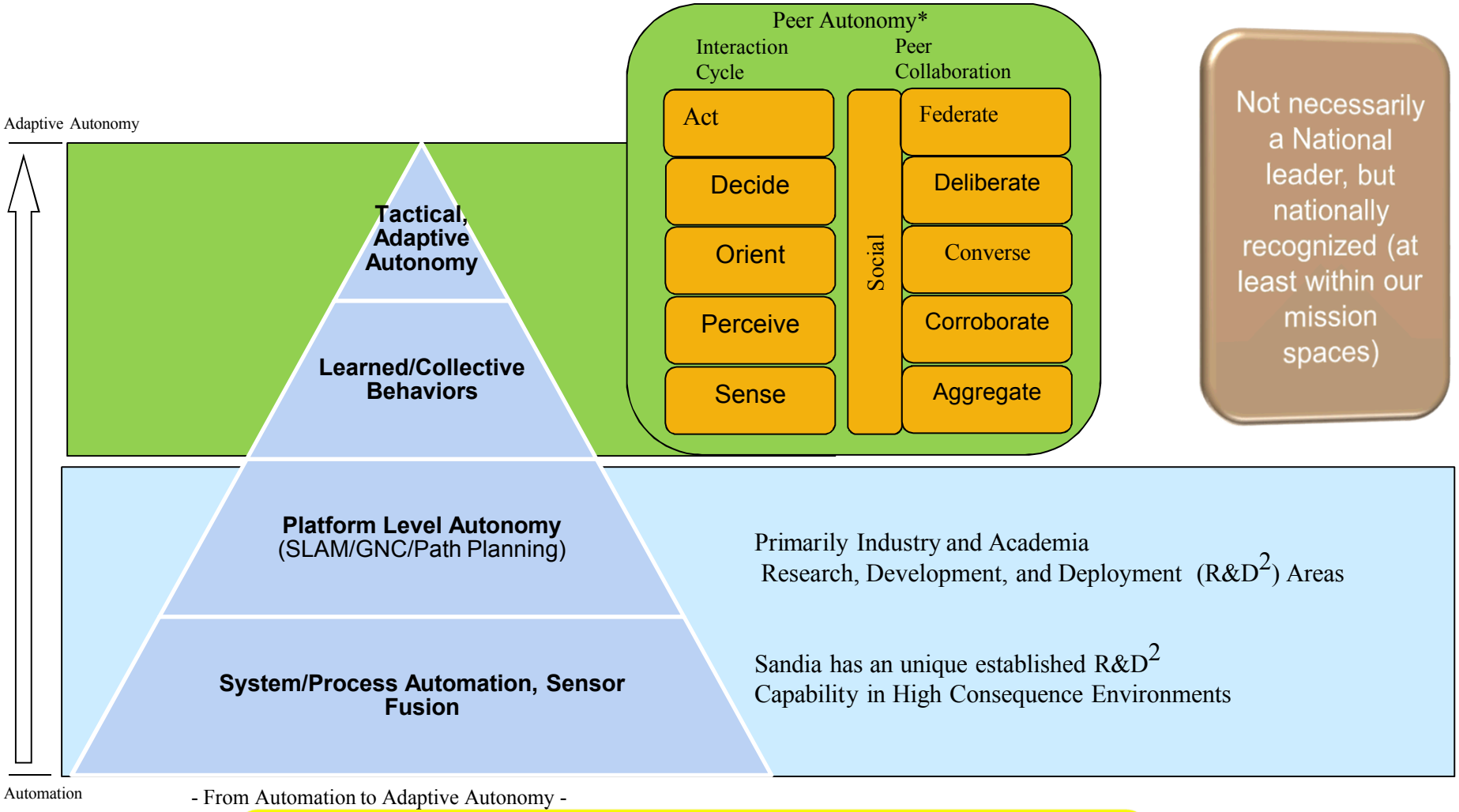
Significant challenges posed by modern technologies that are **automating** everything

Summary

- Broad mission considerations
- A discussion framework is necessary
- Consider how and where autonomy can be applied
- The race for autonomy presents opportunities and challenges
- There are technical and economic challenges

QUESTIONS?

Autonomy Technology Environment



Not necessarily a National leader, but nationally recognized (at least within our mission spaces)

Primarily Industry and Academia
Research, Development, and Deployment ($R\&D^2$) Areas

Sandia has an unique established $R\&D^2$
Capability in High Consequence Environments

* Peer autonomy is collaboration peer-to-peer. Supervised, supervisor and mixed autonomy are other collaboration modes

Levels of System Autonomy

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Level	Observe	Orient	Decide	Act
8	Computer operates without human awareness of this fact	Computer analyzes, predicts, and interprets without human aware of this fact	Computer ranks all tasks without human aware of this fact	Computer executes without any human interaction
7	Computers makes human aware it is gathering, filtering, and prioritizing data	Computer analyzes, predicts, and interprets Human sees results if needed	Computer ranks all tasks and provides limited results without explanation	Computer executes, may inform and allow override later Human shadows
6	Computers gathers, filters, and prioritizes data for the human	Computer analyzes, predicts, and interprets Human shown results	Computer ranks all tasks and provides results and limited rationale to human	Computer executes, informs humans, allows override later Human shadows
5	Computer gathers and filters Human prioritizes data	Computer analyzes, predicts, and interprets Human is back up interpreter	Computer ranks all tasks and provides results and full rationale to human	Computer sometimes allows restricted time for human veto Human shadows
4	Computer gathers data and Works with human to filter Human prioritizes data	Computer analyzes & predicts Human interprets data	Human and computer both rank tasks; computer's results carry most weight	Computer allows restricted time for human to veto Human shadows
3	Computer gathers Human filters and prioritizes	Computer analyzes & predicts Human shadows this and interprets data	Human and computer both rank tasks; human's results carry most weight	Computer executes with human approval Human shadows
2	Human still executes Computer is backup	Human still executes Computer shadows for contingencies	Human ranks tasks Computer acts as tool for some tasks	Human executes Computer shadows for contingencies
1	Human gathers, filters, and prioritizes data	Human analyzes data, makes predictions, and interprets data	Human ranks all tasks	Human executes all decisions