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Artificial Intelligence for Defence

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Colloquium on Artificial Intelligence and Big Data,
19 Mar 2019, Royal Higher Institute for Defence (RHID), Bruxelles, (BE)

OUTLINE

1. Defence research landscape
2. AI research issues
3. AI for Defence
4. AI in EDA
5. Conclusions

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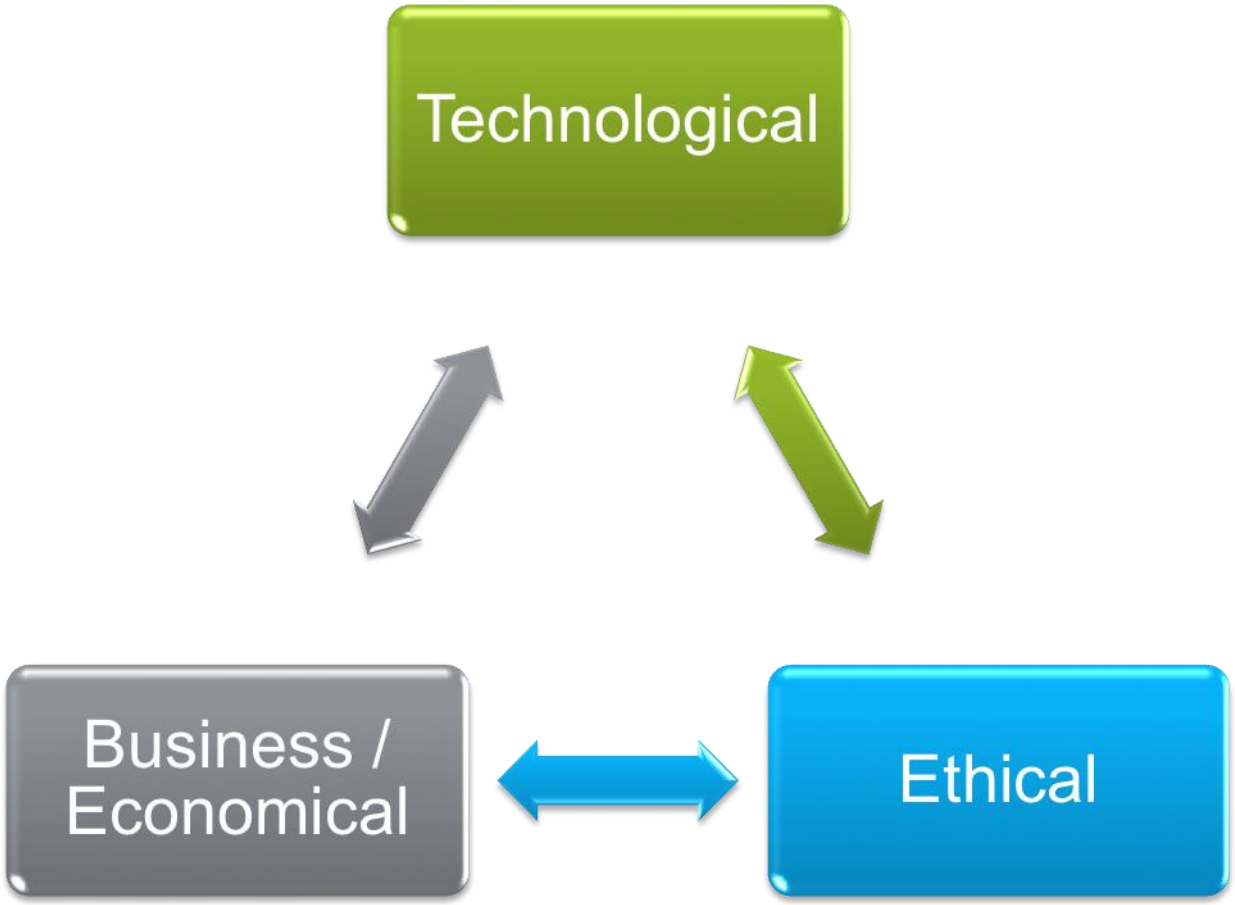
DEFENCE RESEARCH LANDSCAPE

Defence Research framework: Constant Changes

R&D in Defence Challenges



Evolving Threats:
From Conventional to Asymmetric and Hybrid Threats

- Defence products need to be able to comply with a **diverse challenges coming from different operational scenarios**

Conventional

Asymmetric

Hybrid

Defence Business Market Structure

- Defence market is a **monopsony** market
- A market described as monopsony when **only one buyer interacts with many would-be sellers** of a particular product.
- In microeconomic theory of monopsony, **a single entity is assumed to have market power over terms of offer to its sellers**, as the **only purchaser** of a good or service, much in the same manner that a monopolist **can influence the price for its buyers** in a monopoly, in which only one seller faces many buyers.
- The **impact of this market structure** to R&D is manifold
  - **Barriers or high cost to entry**
  - **Regional focus**
  - **Lack of information**
  - **Inhibited Innovation**

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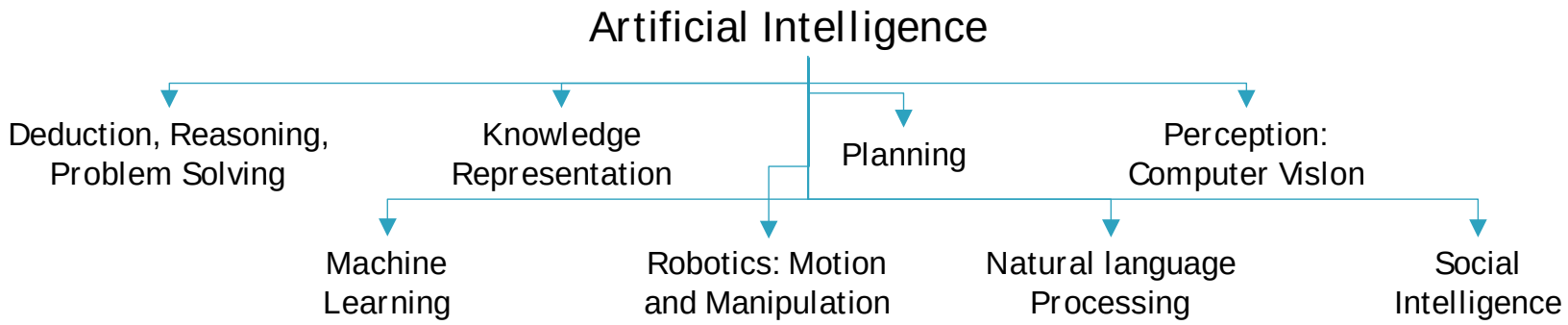
AI RESEARCH ISSUES

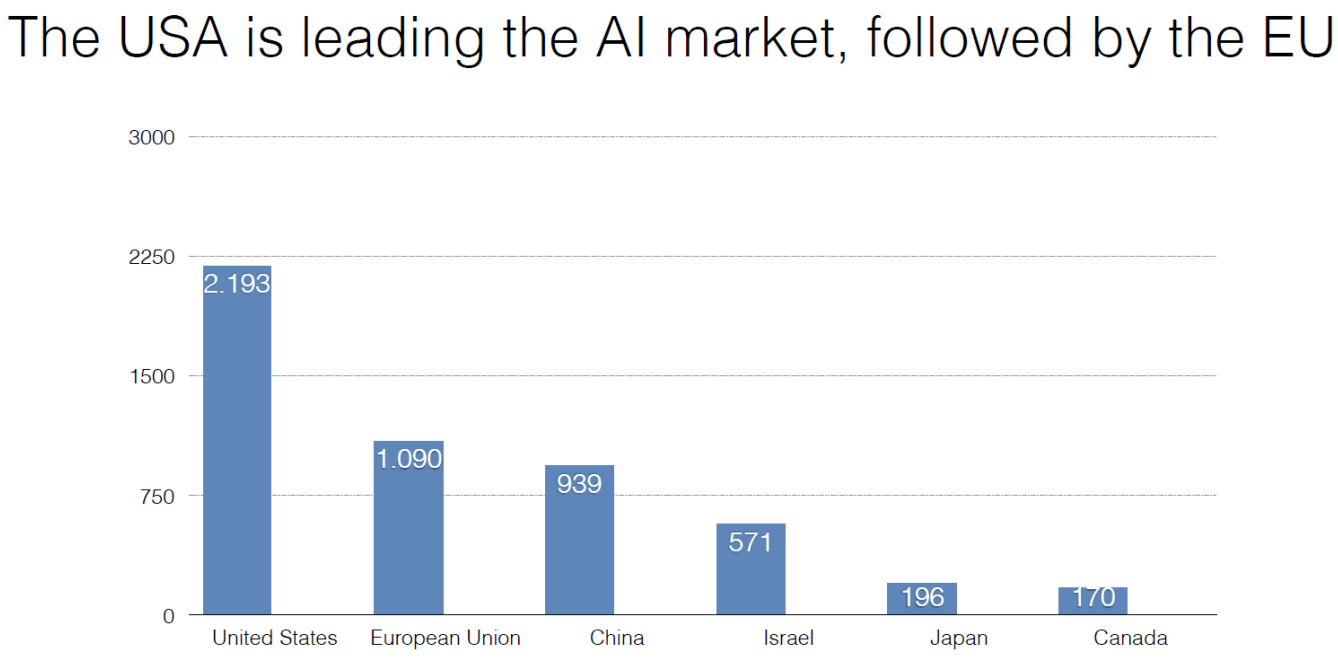
AI R&D areas



Based on Nazre and Garg, "A Deep Dive in the Venture Landscape of Artificial Intelligence and Machine Learning

AI wide scope definition: "the study of the computations that make it possible to perceive, reason, and act"
(Patrick Henry Winston, *Artificial Intelligence*, 3rd ed., 1992.)

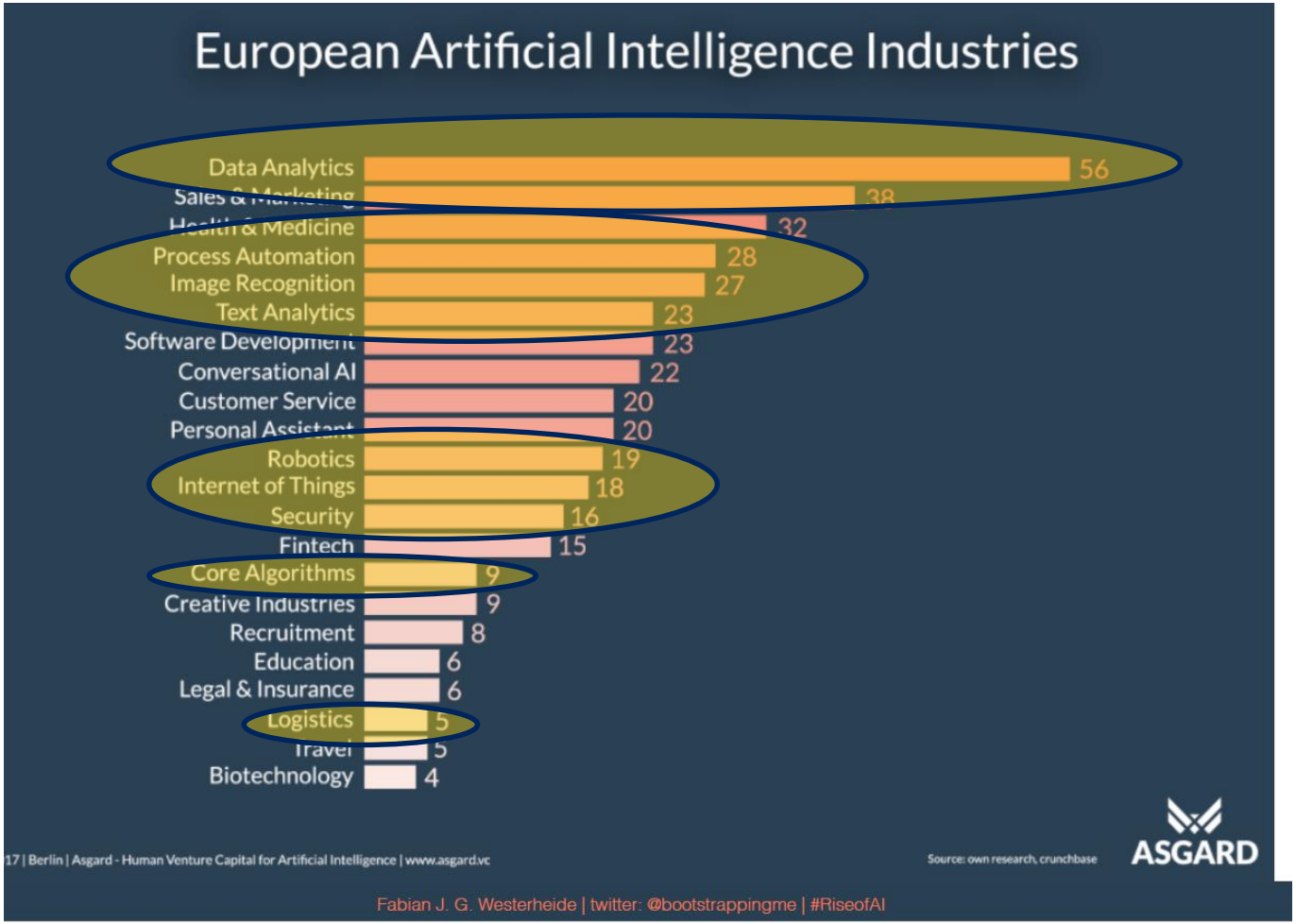
Business: Market Leaders



Source:Westerheide, Fabian J. G.: The European AI Landscape. Presentation at the European Commission AI Workshop, January 2018

Structure of AI ecosystem in EU

Defence Sector not represented



Compliance to Regulations /Standards

Ethical aspects for AI in Defence not yet formal

- An environment under development:
  - **Use AI enabled systems for support and managerial roles instead of combatant** role due to inability to:
    - discern between friend and foe
    - decide about the amount of force considered reasonable in a given situation.
- **Fears of a global AI arms race** that can lead to:
  - the emergence "on the black market of mass quantities of low-cost, antipersonnel microrobots that can be deployed by one person to anonymously kill thousands or millions of people who meet the user's targeting criteria." article on *IEEE Spectrum*
- Key Questions to be answered:
  - Could autonomous armed robots perform more ethically than armed humans in combat?
  - Should we have a "kill" switch to every autonomous robot? (MEPs vote on robots legal status-Jan 2017)

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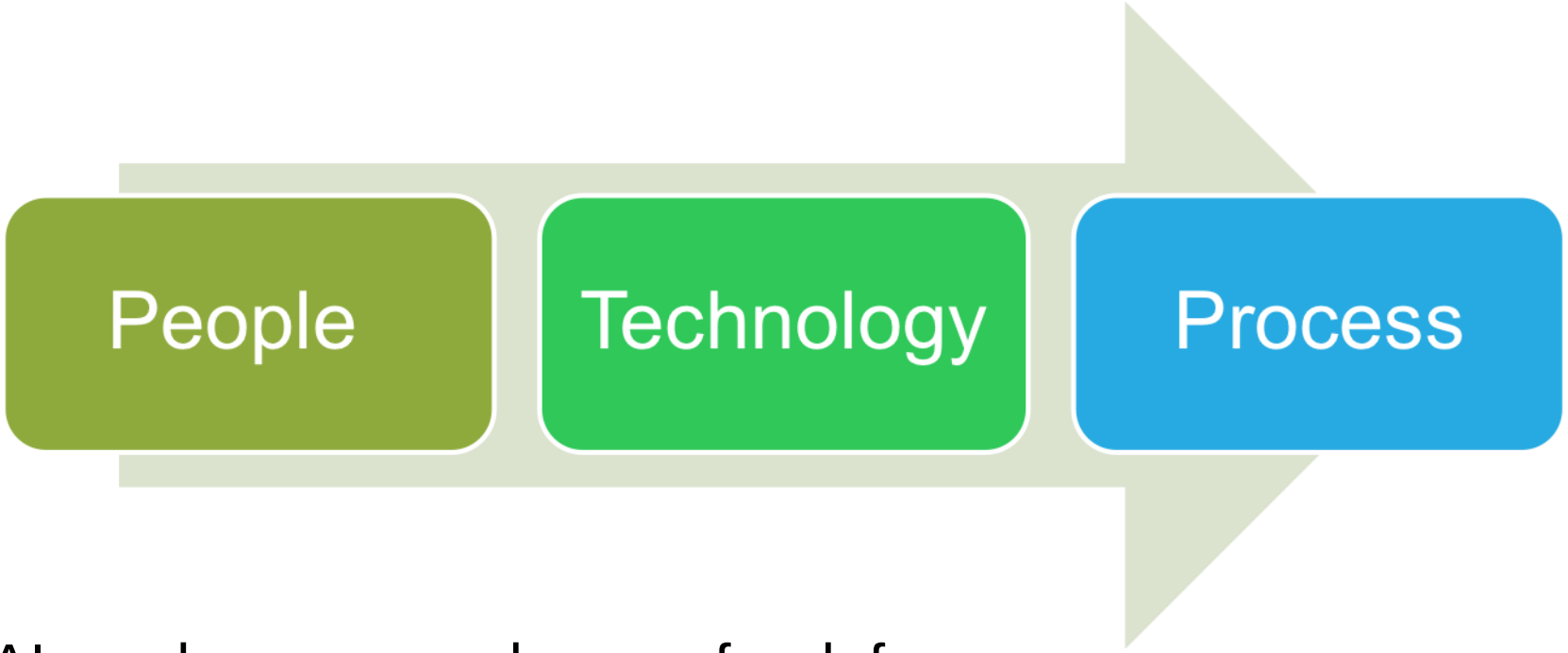
AI for DEFENCE

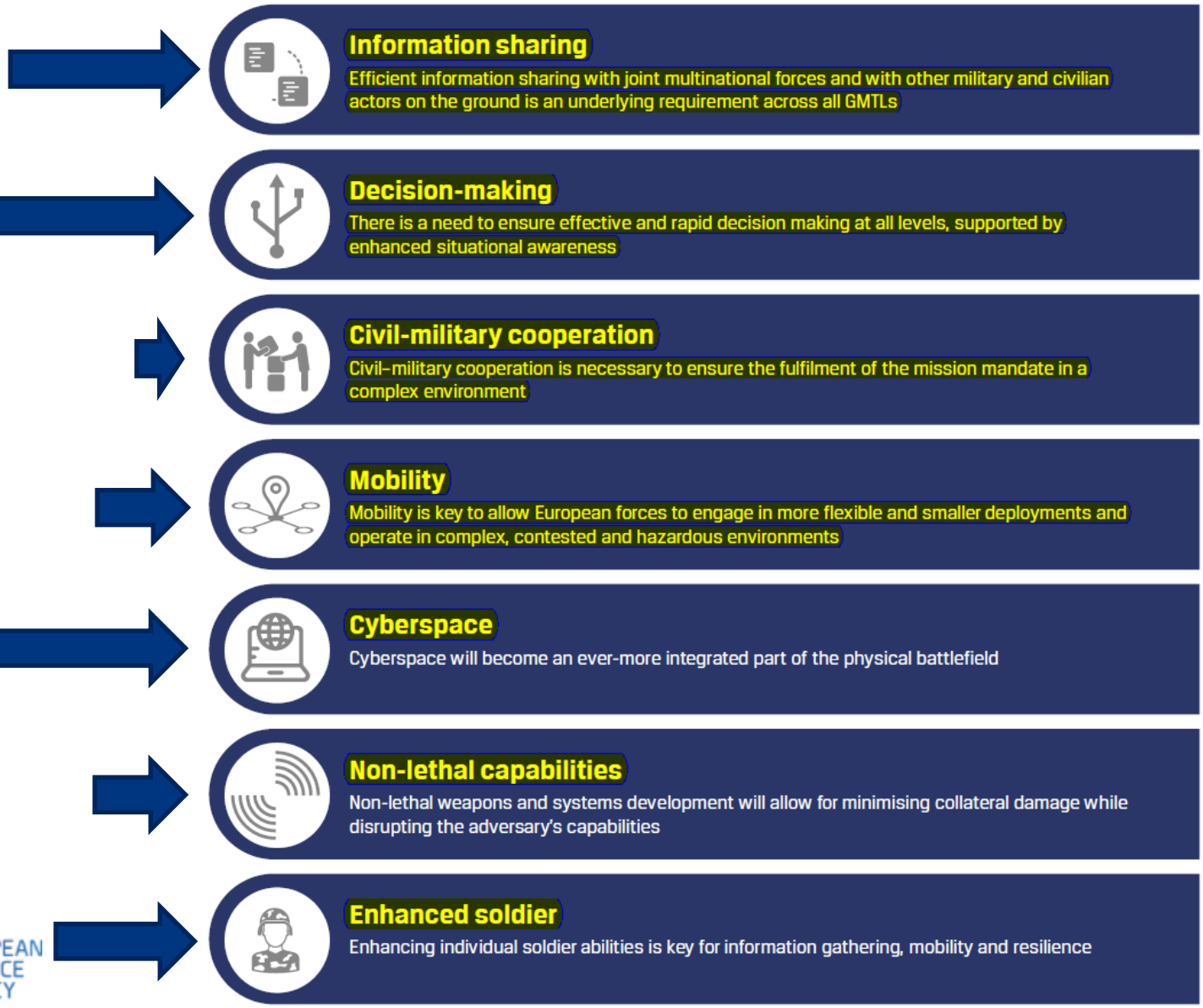
What AI is about for Defence?



- AI can be a game changer for defence:
  - **Reduces risk of life loss** in wars.
  - Can be **more efficient than regular soldiers**.
  - Are **less in cost about ten times** than the cost of human soldiers

KEY TECHNOLOGY 2035 + STRAND B

LONG TERM IMPACT ON MILITARY CAPABILITY 2035+ STRAND B



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eu

AI Defence Research Domains

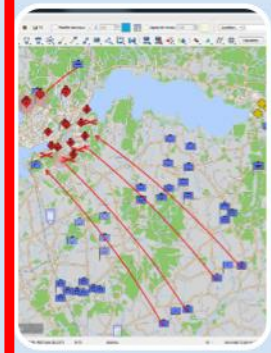
Cyber Defence

Information Management and decision making

Advanced Analytics

-Deep learning

-Machine Learning



Modelling Simulation and Training

Autonomy

-Vehicles (air,sea,land)

-Ammunition

Robotics

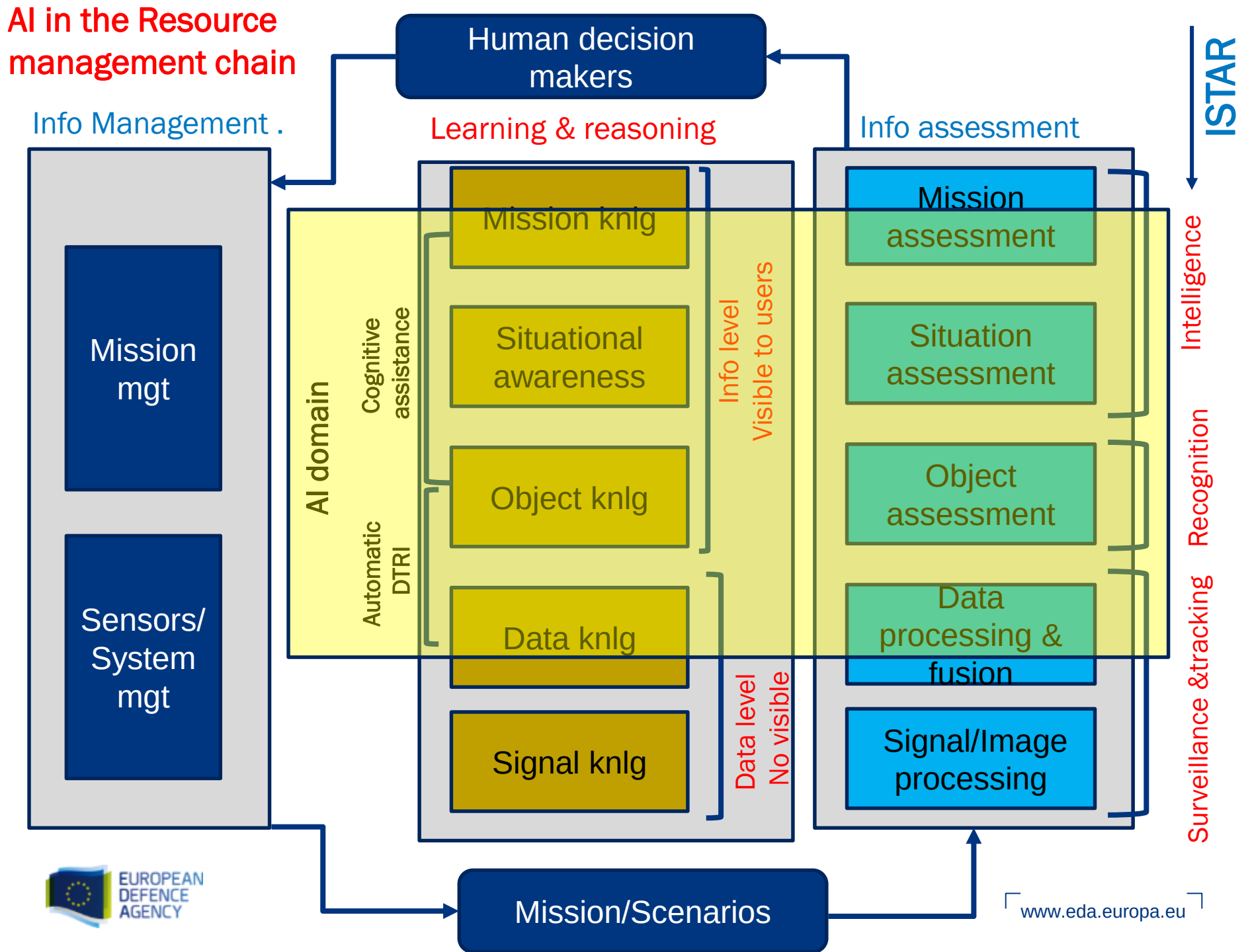
Support (search and rescue)

Logistic Support

(carry equipment)

Operate

(patrol, destroy)


AI in the Resource management chain
Human decision makers
Info Management .
Learning & reasoning
Info assessment
ISTAR
Mission mgt
Sensors/ System mgt
AI domain
Cognitive assistance
Automatic DTRI
Mission knlg
Situational awareness
Object knlg
Data knlg
Signal knlg
Info level Visible to users
Data level No visible
Mission assessment
Situation assessment
Object assessment
Data processing & fusion
Signal/Image processing
Intelligence
Recognition
Surveillance &tracking
Mission/Scenarios
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TOPICS

AI generic technologies for Defence

1. Machine learning (ML) with/without human in the loop
2. Deep learning (DL)
3. Convolutional, Deep, Deep Convolutional, Recurrent NN (CNN, DNN, DCN, RNN)
4. Explainable AI (AI whose actions are easily understood by humans)
5. “Hard” data (multiple signals/images) fusion
6. “Soft” data (Observers, context, semantic, linguistic, taxonomy, ontology) fusion
7. Cognitive sensors
8. Integrated hardware accelerators

AUTOMATIC DTRI

- Background/clutter cancellation
- Object classification and recognition
- Super-resolution
- Change or anomaly detection
- Multisensor signal/image (“hard” data) fusion
- Counter IED

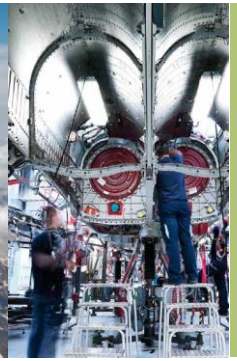
Cognitive assistance (Aid decision making)

- Knowledge based assistance
- Cognitive modelling for adaptive training
- Observers, context, semantic, linguistic, taxonomy, ontology (“soft”data) fusion
- Internet of Battlefield Things—IoBT (Future battlefields to contain millions of networked devices)

AI potential gaps

1. AI&ML/DL robustness and efficiency with small samples, dirty data, high clutter
2. ML and/or DL that is Robust and Resistant to Deceptive and Conflicting Inputs (adversarial)
3. Reasoning about enemy that incorporates distributed learning
4. Adaptive Real-time Learning with Constrained Resources (limited comms, Resource-constrained adaptive computing)

Need of an AI Taxonomy to facilitate research in EU



Interoperability and Common Understanding

- The range of cooperation based on AI can be better understood based on a common AI Taxonomy and definitions

BENEFITS

- Establish a common understanding and facilitate discussions
- Have a solid basis to organize and coordinate future projects
- Improve communication between stakeholders

OUTCOME

- Taxonomy as a common European basis to start analysis of AI Defence needs
- Common mindset to discuss on potential projects based on a solid taxonomy with the understanding of the needs as key to success

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AI in EDA

AI in EDA: highlights

48 related OSRA TBBs

1 related CDP priority

1 technology foresight workshop

3 experts Workshops

EDA Innovation Prize

AI in EDA: some details

Workshop on “Artificial Intelligence for OPTRONICS systems” 22.10.2018, EDA

Workshop on “ AI and Cognitive Technologies for Radar, Comms and EW, 3 and 4 December 2018, EDA premises, Brussels

Technological foresight WS on artificial intelligence, 13-14 Dec 2018, EDA, Bruxelles

14 OB studies launched or to be launched on AI related topics in 2014-2019

8 EDA Cat B & Cat A related projects

1 Workshop on AI taxonomy and high lelvel applications for Defence (Q3 2019)

AI Foresight workshop results

Key Messages From AI (1/3)

- AI is a t**ransformative technology which will impact many of the future systems and military applications**.

- Although clear applications in systems as the FCAS (Future Combact Air Systems) can be identified in the long run, the **key applications identified** as the earliest and with most likelihood and impact in the short run. They are
  - **Decision making in C2,**
  - **Intelligence gathering**
  - **Autonomy**

  Some examples are :
  - Reasoning plus contextual understanding tecniques to enhance the “common sense” in the current AI developments
  - AI driven smart cognitive sensor network combined with Smart and secure communications and channel management. Active learning in real time.
  - Machine learning in engagement

Key Messages From AI (2/3)

- These applications need of three fundamental challenges:

1. The **establishment / development of technological and organizational capabilities** in the:
   i. Verification, Validation, Certification and Trust & Confidence building of AI systems, also ncluding the identification and assessment of the vulnerabilities derived of the organizational implications of AI.

2. **The collection of data to support the (constant) training of the machines**. This collection has several aspects of consideration:
   i. Procedural aspects in the collection among different European countries. Difficulty in a European level Database.
   ii. Data sovereignty (country data parcellation, confidence level parcellation, data integration,…)
   iii. Access to very specific data (because of the sensitive application/source, or because of lack of data).
   iv. Data lifecycle and database management in the defence context
   v. The significant effort needed to train and label data.

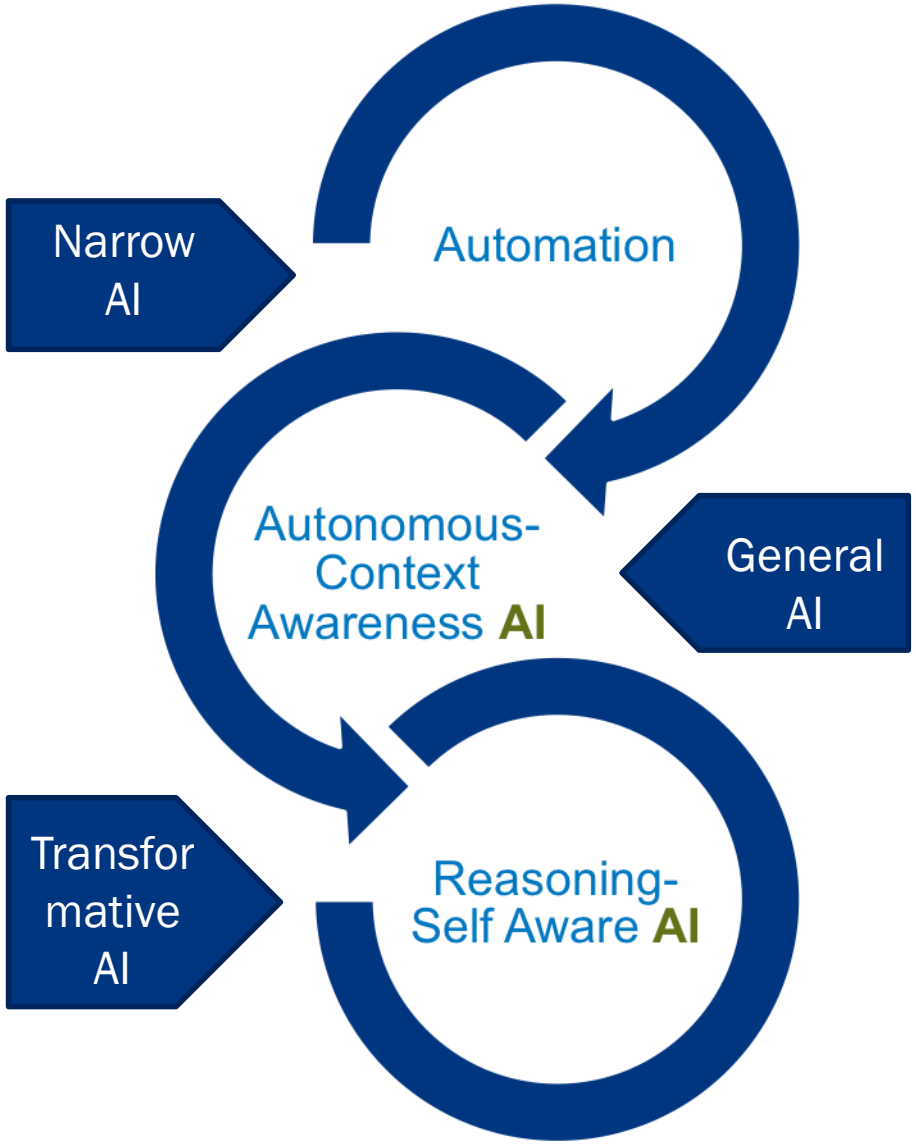
Key Messages From AI (3/3)

- These applications need of three fundamental challenges:

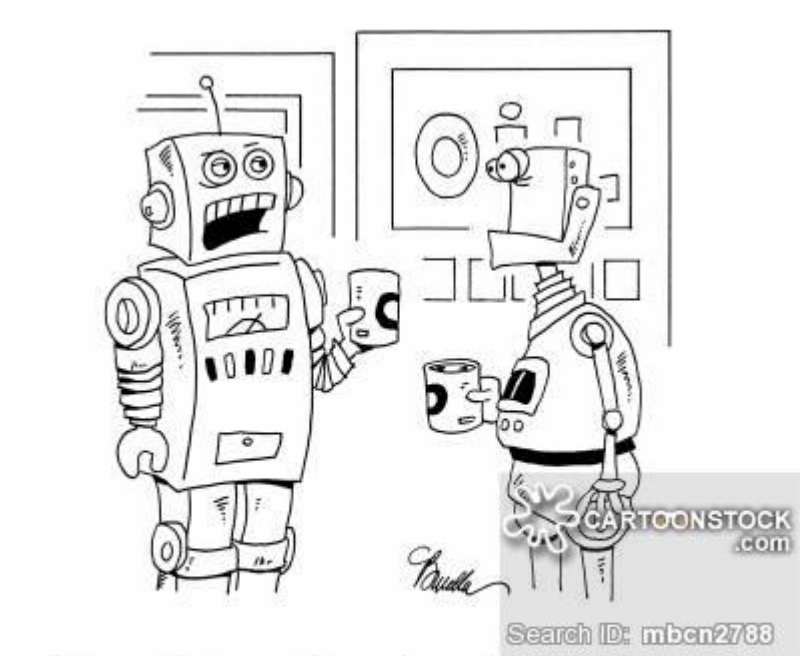
3. The maturation of the following technological aspects:

- Robust and distributed Machine learning
- Knowledge representation (build shared ontology, lifecycle of knowledge representation, ….) and understanding of cognitive states and its impact on human manchine interfaces.
- High performance edge computing
- The specialization in AI of existing/new methods and tools to model, design & simulate new developments in AI.

Looking to the future



- **As the AI research evolves,** so do **AI applications in the military,** e.g. RPAS→ Autonomous UAV → Self-Aware Drones → Drone Swarms (e.g. Perdix)
- **AI is an enabler; but it will also disrupt the current military structures**→ the disruption will be horizontal and vertical→ flexibility and adaptation needed
- **Impact in balance of power vis-à-vis military operations** (first user advantage, adoption capacity theory)
- **Disruption in military organisational** and cultural infrastructures (both in war and peace times)
- **Balance of innovation and application between civil-military** → impact on interoperability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"Sure, it seems harmless, but you hire one human and the next thing you know, they're taking your job."

Questions?