RPAS R&D Roadmap(s)

ART Meeting - September 2015

Eric Hoffman ATM/RDS/ATS
Roadmaps....

- 2005: European Civil Unmanned Air Vehicles - Roadmap, Action Plan, Strategic Research Agenda (FP5 (UAVNET, CAPECON, USICO))
- 2008: Study Analysing the current activities in the field of UAV: Way forward (DG Enterprise)
- 2008: Roadmap for the seamless integration of UAS within General Air Traffic by 2015 (EDA)
- 2010: Regulatory Roadmap for UAS Integration (FP6 (INOUI))
- 2012: ICAO Global Plan / ASBUs
- 2012: NextGen UAS Research, Development and Demonstration Roadmap
- 2013: Roadmap for the integration of civil Remotely-Piloted Aircraft Systems into the European Aviation System (European Commission)
- 2013: Master plan relative to the insertion of remotely piloted aircraft systems in (RPAS) in the European air transport system (FP7 (ULTRA))
- 2013: EDA Research & Technology Joint Investment Programme
- 2013: FAA Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap
- 2015: SJU RPAS definition phase
- 2015: RPAS R&D in EASA Concept of Operations for Drones
- 2015: EU ATM Master Plan
Past RPAS R&D actions
Framework Programme 7 (FP7)

- 2006 – 2014
  - Approx. 19 RPAS (drones/UAV/RPAS) related activities,
  - Approx. 120M€

- Different areas of applications for drones were investigated:
  - border control
  - policing and internal security (e.g. to stop non-cooperatives vehicles or counter the use of drones by terrorists)
  - search and rescue applications
  - environmental survey
  - agricultural
  - ocean observation
  - fire-fighting
  - chemical sensing
Five guiding principles:

- RPAS need to be treated as new types of aircraft with proportionate rules based on the risk of each type of operation
- EU rules for the safe provision of RPAS services need to be developed now
- Technologies and standards need to be developed for the full integration of RPAS in the EU ATM system
- Public acceptance is key to the growth of RPAS services
- RPAS operator is responsible for its use
2013 EC RPAS Roadmap
Context & objectives


– **Safe integration of RPAS** into the European aviation system -> the main priority to support the development of this sector in Europe.

– Mandate to European RPAS Steering Group (ERSG) to establish a Roadmap, aiming at initial RPAS integration by 2016.
2013 EC RPAS Roadmap
ERSG participants

- **Major stakeholders** interested in the integration of RPAS into the European aviation system.

- EASA, EUROCONTROL, EUROCAE, SESAR JU, JARUS, ECAC, EDA, ESA, ASD, UVSI, EREA and ECA.

- Handed over to the European Commission in June 2013.
2013 EC RPAS Roadmap
Main Outcomes

- 3 main aspects:
  - Regulation,
  - Strategic Research and
  - Societal Impact.

- Different types of operations:
  - **Very low level (VLL)** operations (i.e. below 500 ft), either in Visual line of sight (VLOS), possibly extended thanks to observers (e-VLOS) or beyond (B-VLOS)
  - **RPAS operations in VFR or IFR** (above 500 ft) within or beyond radio line-of-sight (RLOS or BRLOS)
2013 EC RPAS Roadmap
Progressive integration

- **Not all** the key technologies for integration of RPAS with ‘manned’ aviation **mature** and standardized.

- **Gradual and evolutionary** RPAS insertion in airspace over 15 years:
  - Initial operations (under CAA restriction, mostly in segregated airspace)
  - Integration (alleviation of restrictions/limitations through harmonized regulations)
  - Evolution (complete integration into European civil aviation system)
2013 EC RPAS Roadmap
R&D perspective

- **Airspace access and surface operations**
  - set requirements for minimum IFR performance, CNS, contingency, automatic landing, ATC, etc.

- **Comms C2 data link**
  - assess impact on ATM communication systems, including capacity and performance requirements, command and control communications requirements, safety and security considerations, integrity, continuity, availability of data link and spectrum.

- **Detect & Avoid**
  - Enhanced situational awareness, collision avoidance, traffic avoidance function, interoperability with other safety nets, etc.

- **Human Factors**
  - definition of role and responsibilities RPAS, ATC, other users..

- **SESAR compatibility**
  - mapping to ATM Master Plan, trajectory management for RPAS, initial 4D trajectory operations, SWIM, etc.

- **Contingency**
  - transparent contingency procedures and loss link procedures.

- **Security**
  - security of ground station and remote pilot, unlawful interference, jamming, spoofing, security of data link, etc.)
2013 EC RPAS Roadmap Schedule
# 2013 EC RPAS Roadmap

## Effort evaluation

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<tr>
<td>Activity 1</td>
<td>EVLOS/VLOS, Human Factors</td>
<td>Evaluation of simulation tools</td>
<td>Q1</td>
<td>Q2</td>
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<td>Activity 2</td>
<td>EVLOS/VLOS, Operations in urban areas</td>
<td>Validation of Models and Prototypes</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
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<tr>
<td>Activity 3</td>
<td>EVLOS, Human Factors</td>
<td>Critical Information Assets</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
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<td>Activity 4</td>
<td>IFR/VFR, Visual detectability solutions and detectability of the RPA by sensors</td>
<td>OSIRIS, SPS, SPS, TIF</td>
<td>Q1</td>
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<td>Activity 5</td>
<td>IFR/VFR, Detect and Avoid</td>
<td>Validation Exercise</td>
<td>Q1</td>
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<td>Activity 6</td>
<td>BVLOS, Detect and Avoid</td>
<td>Validation Exercise</td>
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<td>Activity 7</td>
<td>IFR/VFR, Comms C2 datalink</td>
<td>Validation Exercise</td>
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<td>Activity 8</td>
<td>BVLOS, Comms C2 datalink</td>
<td>Validation Exercise</td>
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<td>Activity 9</td>
<td>IFR/VFR, Airspace Access and Airport Operations</td>
<td>Validation Exercise</td>
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<td>Activity 10</td>
<td>BVLOS, Airspace Access and Airport Operations</td>
<td>Validation Exercise</td>
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<td>Activity 11</td>
<td>IFR/VFR, Contingency</td>
<td>Validation Exercise</td>
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<td>Activity 12</td>
<td>IFR/VFR &amp; BVLOS, Human Factors</td>
<td>Validation Exercise</td>
<td>Q1</td>
<td>Q2</td>
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<td>Q4</td>
<td>Q1</td>
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<td>Activity 13</td>
<td>Security</td>
<td>Validation Exercise</td>
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<td>Activity 14</td>
<td>Demonstrations of best practices</td>
<td>Validation Exercise</td>
<td>Q1</td>
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<td>Q4</td>
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<td>Q2</td>
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EASA Concept of Ops for Drones

A-NPA 2015-10: Introduction of a regulatory framework for the operation of drones

- Concept of operation for drones (May 2015):
  - risk based approach,
  - broad range of operations and types of drones

- Proposes three categories of operations and associated regulations:
  - **Open operation**, no authorization by an Aviation Authority for the flight. Drones within defined boundaries for the operation
  - **Specific operation**, risk assessment leading to an Operations Authorisation with specific limitations.
  - **Certified operations**, operations with higher associated risk or might be requested on a voluntary basis by organisations providing services such as remote piloting or equipment such as “detect and avoid”.
EASA Concept of Ops for Drones
Main R&D elements

- 7 key research areas for the integration in non-segregated airspace:
  - Detect & avoid
  - Airspace and Airports access
  - Command and Control (C2) communications
  - Human factors
  - Contingency
  - Security
  - Autonomy

- Further research to be performed by:
  - SESAR and
  - the European Defence Agency (EDA)
  - ...

  - Cooperation, synergies and no duplications of work.
**EASA Concept of Ops for Drones**

**Additional R&D elements**

- Several possible additional research threads:
  - Transfer of drones between control stations (e.g. long range drones)
  - One control station controlling several drones (e.g. formation flights)
  - ATC and drones operational control performed by the same person
  - Communications with ATC with an acceptable time of latency
  - **Full autonomy** and cooperative operations (e.g. operation in swarms; network centric operations)
  - Extreme endurance (several days or months) at very high altitude (20,000 m): specific requirement to maintain the vigilance and face emergencies
SJU RPAS Definition Phase

- End 2013: EC mandate to SJU to define future ATM RPAS R&D
  - Full alignment with ongoing SESAR activities and existing requirements for manned aviation.
- 9 SESAR demonstration activities on RPAS to assess the integration of RPAS in non-segregated airspace.
- Based on results of those activities, SJU started to SESAR RPAS Definition Phase. -> Still on going
- Principles:
  - Link to the EU ATM Master Plan
  - Link to ICAO Global Plan/ASBU timeline
  - RPAS should fit into the ATM system (and not the reverse)
  - as safe as current manned aircraft operations
  - with a behavior equivalent to manned aviation.
SJU RPAS Definition Phase

R&D main areas

- Seven main areas of R&D identified:

  - **Detect and avoid**: to ensure that RPAS have the same capability as manned aircraft to avoid hazards (other aircraft, obstacles, terrain, severe weather conditions and wake turbulence)
  - **C2 data link capabilities**: to build an adequate and reliable command and control system of the remotely piloted aircraft
  - **Airspace access and airport operations**: to address the performance threshold for RPAS to seamlessly integrate with manned aircraft in all types of airspace classes and airports
  - **Contingency**: to ensure a harmonized approach for the air traffic control system to handle failure modes
  - **Human factors**: to address the specificity of human factors aspects of RPAS and their interaction with the ATM and other airspace users;
  - **Security**: to address cyber-resilience to ensure safe RPAS operations;
  - **Coordination of demonstrations and validations activities**: to harmonise the RPAS developments and integration activity.
SJU Work Programme
Ongoing activities

- Initial activities:
  - 9 RPAS demonstration projects (4 M€ at 50% cofounding, max 500K€ per project) between the third quarter 2013 and end 2015
    - University of Barcelona - Spain
    - study RPAS operating under an IFR - ATM
    - benefits that technology and
    - first quarter 2013 to first quarter 2016, about 500K€.
### SJU RPAS Demonstration Projects (1)

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Countries</th>
<th>Scope</th>
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<tbody>
<tr>
<td>AIRICA</td>
<td>Netherland</td>
<td>To demonstrate realistic coastguard missions in the North Sea area, with flights Beyond Visual Line Of Sight.</td>
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<tr>
<td>ARIADNA</td>
<td>Spain</td>
<td>To validate the use of RPAS using unmanned helicopter procedures.</td>
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<tr>
<td>CLAIRE</td>
<td>United Kingdom</td>
<td>To investigate different classes of airspace and flight modes including airfield CTA and ground operations.</td>
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<tr>
<td></td>
<td>Netherlands</td>
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<tr>
<td>DEMORPAS</td>
<td>Spain</td>
<td>To carry out different flight demonstration exercises with RPAS.</td>
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<tr>
<td>INSuRE</td>
<td>Czech Republic</td>
<td>To assess the enablers (technological, operational procedures, and safety aspects) to allow safe integration of RPAS into a non-segregated airspace.</td>
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## SJU RPAS demonstration projects (2)

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Countries</th>
<th>Scope</th>
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<tbody>
<tr>
<td><strong>MedALE</strong> Mediterranean ATM Live Exercise</td>
<td>Italy</td>
<td>To demonstrate the validity and limits of the ad-hoc operational procedures and airworthiness rules as well as of the existing technologies and systems. Exploring the requirements for RPAS insertion into non-segregated airspace.</td>
</tr>
<tr>
<td><strong>ODREA</strong> Operational Demonstration of RPAS in European Airspace</td>
<td>France</td>
<td>To measure the impact of having several RPAS in the arrival, approach and departure procedures in a Terminal Area.</td>
</tr>
<tr>
<td><strong>RAID</strong> RPAS ATM Integration Demonstration</td>
<td>Italy, Malta</td>
<td>To demonstrate and evaluate the impact of RPAS integration into unrestricted airspace of current ATM environments. The project will concentrate on the short term implications of integration.</td>
</tr>
<tr>
<td><strong>TEMPAERIS</strong> Testing Emergency Procedures in Approach and En Route Integration Simulation</td>
<td>France</td>
<td>To investigate RPAS performance in low-medium TMA airspace. Providing conclusions on low-performance RPAS, including communications latency, operational latency (e.g. compliance with ATC instructions) and handling of non-nominal situations.</td>
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</tbody>
</table>
EU ATM Master Plan
Overview

– RPAS not included in October 2012 version
– 2015 Draft version:
  ● Remotely Piloted Aircraft Systems (RPAS) as airspace users
  ● Inclusion of all air vehicles into the airspace (including RPAS),
  ● integration in an efficient and non-discriminatory manner while ensuring safety, as an explicit objective.
EU ATM Master Plan
R&D Activities

- Key R&D activities shall address:
  - IFR RPAS Integration:
    - Technical capability or procedural means to allow RPAS to comply with ATC instructions.
  - Airborne Collision Avoidance for RPAS (ACAS Xu)
    - taking into account the operational specificities of RPAS.
  - Surface operations by RPAS
    - To the maximum extent possible, RPAS will have to comply with the existing rules and regulations
  - Airborne Detect and Avoid (D&A) Systems
    - Replicate the human ability to see and avoid.
    - Essential capability as cornerstones of aviation called “rules of the air” in which the pilot is ultimately responsible for the safety of the flight.
SJU Work Programme
Future activities (1/2)

- SESAR 2020 Work Programme 2016+:
  “civil RPAS will integrate safely and transparently in non-segregated airspace, in a multi-aircraft and manned flight environment, guaranteeing the interoperability with the ATM system.”

- Exploratory Research topics:
  - RPAS integration
  - Required enablers for Very Low Level flight of RPAS.
SJU Work Programme
Future activities (2/2)

- **Industrial Research & VLD:**
  - RPAS & surface operations and airport safety nets (PJ03)
  - IFR RPAS Integration (PJ10)
  - Safety nets (PJ11)
  - Technological needs and enablers (PJ13).

  - During iterative refinement process scope of PJ13 reduced:

    - Dow draft 0.91 (early 2015): 4 main themes (*Detect and Avoid, Command and Control, Detectability and Very Low Level (VLL) Operations*) further detailed in 9 solutions.
    - SESAR 2020 Multi-annual Work Programme V1.0 (July 2015): one single solution related to RPAS (*Airborne Detect and Avoid Systems* supporting integrated RPAS operations).
European Defence Agency (EDA) RPAS R&D

- Five main RPAS working areas:
  - Integration of military RPAS in non-segregated civilian airspace
  - Certification of future military RPAS
  - Development of cutting-edge technologies for future European RPAS
  - Establishment of a community of military RPAS users in Europe
  - Support to the development of a European medium-altitude long endurance (Male) RPAS to be operational by 2025

- EDA Research & Technology Joint Investment Programme (JIP) on RPAS launched in November 2013,
  - R&D projects for the development of key technological enablers for the safe integration of RPAS into non-segregated airspace.
  - 10 participating states (Austria, Belgium, Czech Republic, Spain, France, Italy, Poland, Sweden and the United Kingdom), + 2 in the process of joining (Portugal and Slovenia).
## EDA R&D projects

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<th>Scope</th>
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<tr>
<td><strong>MIDCAS</strong></td>
<td>Sweden, France, Germany, Italy and Spain</td>
<td>2009 – 2015: to demonstrate the sense and avoid function for RPAS, providing the technical content of a collision avoidance system standard proposal and to contribute to the RPAS integration in civilian airspace by proposing a baseline of solutions for the &quot;Unmanned Aircraft System Mid-air Collision Avoidance Function&quot; acceptable by manned aviation. Total budget of €50 million.</td>
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| **DeSIRE**  | European Space Agency, Spain | 2 Campaigns:  
• 2012- 2013: to demonstrate the safe integration of RPAS in non-segregated airspace using satellites capabilities for RPAS command and control, air traffic control communications and mission data transfer to ground, in order to satisfy the needs of potential user communities.  
• 2014 – on going: contribute to prepare a midterm development of RPAS independent satellite data-link service, with the involvement of rulemaking stakeholders (addressing critical certification and rulemaking). Total budget €2.6 (ESA €, EDA €600.000 and €800.000 by the industrial consortium). |
| **ERA**     | France, Germany, Poland, Sweden and Italy | 2015 – on going: to establish the technological baseline for automatic take-off and landing, auto-taxi, nominal/degraded mode automation functions and emergency recovery. Providing support to the regulation and standardization of these capabilities, conducting safety assessments, and defining procedures. |
## R&D areas comparison table

<table>
<thead>
<tr>
<th>RPAS Roadmap</th>
<th>SJU Definition</th>
<th>EASA</th>
<th>ATM Master Plan 2015 (Draft)</th>
<th>SJU Multi Annual</th>
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<tr>
<td>D&amp;A</td>
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<td>Comms C2 data link</td>
<td>C2 data link capabilities</td>
<td>Command and Control (C2) communications</td>
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<tr>
<td>Airspace access &amp; surface operations</td>
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<td>Airborne Collision Avoidance for RPAS (ACAS Xu)</td>
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General Presentation 26
Conclusion / Questions

- Clear European political will to progress on RPAS
  - Ambitious timescales for R&D / slow progress so far.
- Many actors involved
- Many topics identified – not all addressed
  - Regulation
    - Addressed by EASA
  - Strategic Research
    - De facto prioritization / focussing on:
      - VFR/IFR Operations (vs. VLL)
      - D&A
  - Societal Impact
    - Acknowledged but not that obvious in calls/plans

- RPAS community spans between:
  - ICAO Aviation world
  - Internet world
- Bias/ partial coverage of current RPAS R&D Roadmaps?
- Involvement in European R&D of parties outside of the Aviation world? SMEs?
- R&D on the steps beyond, eg autonomy?
Additional slides
US R&D Activities – FAA (1/2)

- R&D Topics:
  - System Safety & Data Gathering,
  - Aircraft Certification,
  - Command & Control Link Issues,
  - Control Station Layout & Certification,
  - Ground & Airborne Sense & Avoid, and
  - Environmental Impacts.

- UAS Centre of Excellence:
  - Mississippi State University and 15 universities.
  - Research education and training on UAS integration
US R&D Activities – FAA (2/2)

- 6 UAS research and test sites:
  - University of Alaska: incl. standards for UAS categories, state monitoring, safety standards for UAS operations.
  - State of Nevada: incl. air traffic control procedures for the introduction of UAS into the civil environment and UAS integration with NextGen.
  - New York’s Griffiss International Airport: incl. Investigating sense and avoid capabilities for UAS.
  - North Dakota Department of Commerce: incl. Conduct human factors research.
  - Texas A&M University: incl. airworthiness testing.
  - Virginia Tech: incl. conduct UAS failure mode testing and identify and evaluate operational and technical risks areas.

- Pathfinder Program:
  - Identify the safety mitigation to expand UAS access.
  - Partners:
    - CNN (VLOS operations for newsgathering in urban areas),
    - Precision Hawk (EVLOS agricultural operations in rural areas) and
    - BNSF Railway (BVLOS inspection of rail infrastructure).
US R&D Activities - NASA

- **Research Themes:**
  - **UAS Integration** - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system
  - **Test Infrastructure** - Test infrastructure to enable development and validation of airspace integration procedures and performance standards

- **NASA UAS-NAS research project activities:**
  - **Sense and Avoid** (SAA)
  - **Command and Control** (C2)
  - **Human Systems Integration** (HIS)
  - **Integrated Test and Evaluation** (IT&E):
    - live virtual constructive (LVC) distributed environment (DE)
    - test scenarios supporting integration of UAS into the NAS.
US R&D Activities – NASA UAS Traffic Management (UTM)

- Many civilian applications of Unmanned Aerial System (UAS) will operate at lower altitude (Class G, 2000 Feet) (e.g. Humanitarian, Goods delivery, Agricultural services, Strategic assets surveillance such as pipelines.)
- No infrastructure to safely support these operations is currently available.
- UAS operations will be safer if a UTM system is available to support the functions associated with:
  - Airspace management and geo-fencing (reduce risk of accidents, impact to other operations, and community concerns)
  - Weather and severe wind integration (avoid severe weather areas based on prediction)
  - Predict and manage congestion (mission safety)
  - Terrain and man-made objects database and avoidance
  - Maintain safe separation (mission safety and assurance of other assets)
  - Allow only authenticated operations (avoid unauthorized airspace use)
US R&D Activities – NASA
Autonomy Strategy Framework

- **Vision:** Autonomy (capacity of UAS to perform mission without a direct pilot control) is implemented in harmony with humans to maximize the benefit of aviation to society.

- **Needs:**
  - **Technologies & Applications:** model autonomy standards, technologies, functions and mission applications to broadly enable innovation.
  - **Trusted Systems Integration:** address the challenges associated with trust between humans and autonomous systems, including certification, verification and validation, and user/public acceptance.
  - **Architectures, Methods & Metrics:** develop architectures and meta-design tools that enable the efficient and effective creation of joint human-machine cognitive systems.
  - **Real World Testbeds:** establish and maintain the relevant environment and testbeds for developing technologies, concepts and architectures and testing autonomous systems.

- **Challenges:**
  - Technical (Research to Enable): Issues such as human-machine collaboration, TEV&V, machine reasoning, sensor integration, etc.
  - Socio-Policy (Research to Inform): Issues such as liability, public acceptance, moral decision-making, transformation of human roles/tasks, etc.
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