UNIVERSIDAD POLITÉCNICA DE MADRID

GINA

GRUPO DE INVESTIGACIÓN DE NAVEGACIÓN AÉREA

PAVING THE WAY TOWARDS FUTURE ATM.
A wide range for research.

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PAVING THE WAY TOWARDS FUTURE ATM.

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ATM role: 4D Trajectory Management.

It is commonly recognised that 4D trajectories management in a safety and efficient manner has been always the goal of the ATM. And it will be the basis for the future ATM system eliminating or overcoming the capacity limitations derived from a human centre concept of operation.

The starting line: SES/SESAR and NextGen.

- In order to fully meet the safety, capacity and other performance targets of the foresee ATM System in 2020/2025 several parading shifts are required.

  ◦ 1.– **Shift from airspace – based operation towards a trajectory – based operation concept.** Aims to ensure that the Airspace User flies its trajectory close to its intent in the most efficient.
  ◦ 2.– **Shift from tactical management towards a more strategic system**, implementing different planning layers where decision about trajectories can be taken in advance to accommodate user needs, de–conflict trajectories and reduce us much as possible human tactical intervention over the aircraft.
  ◦ 3.– **Shift from a controller based system towards a more distributed system** on which decision about aircraft trajectories could be taken by the actor that is best place at each moment and each scenario to take such decision.

Paradigm shift in ATM in the long term (beyond 2025).

FOCUS ON ATM INVARIANT PROCESSES

CHANGES DRIVEN BY OVERALL SYSTEM PERFORMANCE

4D TRAJECTORY MANAGEMENT

(ANTICIPATED CONTROL,

COMPENSATORY CONTROL)

NEW ROLES ASSIGNMENT BASED ON: "DECISION PLACE", "BEST PLAYER" AND "BEST TIME"

Focus on ATM invariant processes

Lets consider ATM system is constituted by a set of invariant process:
"the core processes that are the essential components in making ATM work.": separation assurance, flights efficiency, aerodrome constrains.

▸ Invariant process can have different instantiations depending on the:
  ◦ role of the actors,
  ◦ operational concepts drivers,
  ◦ supporting technology,
  ◦ level of automation,…

▸ When trying to answer these principal questions others related questions will pop up.
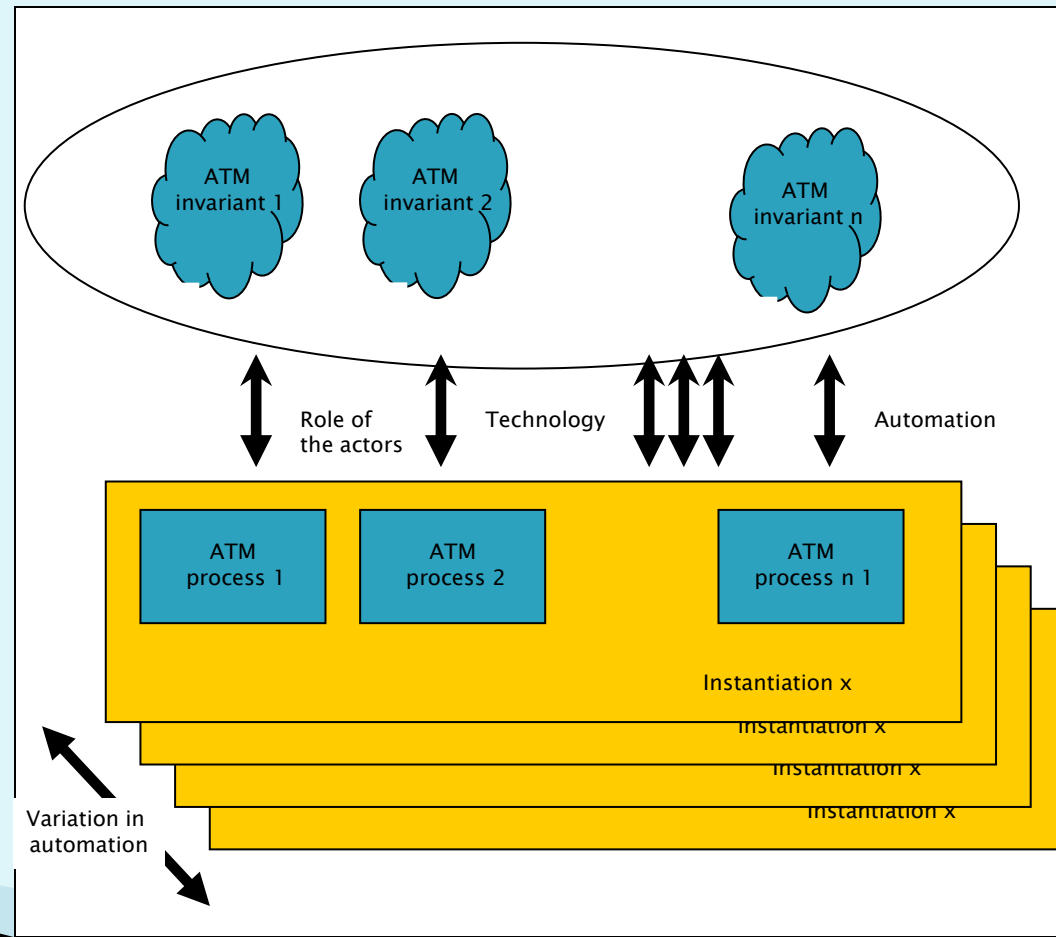
The meaning of 4D Trajectory Management, planning layers.

Working with what is planned to happen: **Trajectory planning**: Centralised Management?

Working with what is actually happening: **Trajectory Tracking**: Autonomous Management?

Targeting
- Situation assessment
- Current understanding
- Goals/Targets

Monitoring
- Information
- Goals/Targets
- Plans/Objectives

Regulating
- Situation assessment
- Plans/Objectives
- Actions/Target values

Tracking
- Measurements/Feedback
- Actions/Target values
- Corrective actions
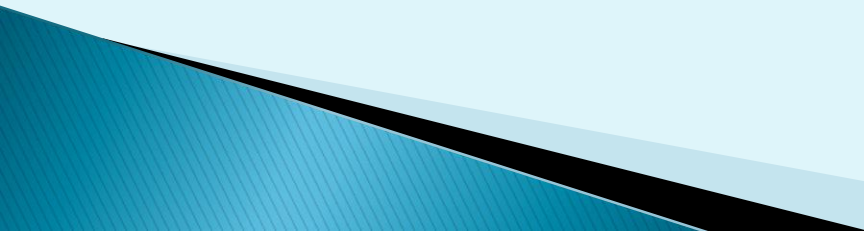
Anticipated control

Compensatory control

Figure taken from Erik Hollnagel

Overall system performance as main driver for the paradigm change.

- Best placed actor would take the best decision at each moment and in each scenario.
- Automation at the right function and at the right level is required element to eliminate or overcome the capacity limitations derived from a human centre concept of operation.
- New role for the different actors in the long term future ATM is, even today, a matter of conceptual proposals; **impact on overall system performance should be the main driver.**

The three interdependent dimensions for the paradigm change.

- First dimension "best time" for decision making: Strategic vs. tactical planning layer.
- Second dimension "decision place": centric vs. autonomy.
- Third dimension "best player": Human vs. automated player.

First dimension "best time" for decision making: Strategic vs. tactical layer questions to be answered:

DO STRATEGIC FUNCTIONS IMPLY MORE COMPLEX AND RIGID OPERATIONAL SCENARIOs?

AS ATM PROCESSES, AT DIFFERENT PLANNING LAYERS, WILL HAVE FEEDBACK TO ABSORB UNEXPETED CHANGES: WILL THE OVERALL SYSTEM (COMPOSED BY DIFFERENT NESTED LOOPS) MAINTAIN THE REQUIRED STABILITY?

STRATEGIC (Target) VS. TACTICAL (Tracking)

WHAT IS THE IMPACT OF UNCERTAINTIES IN A SYSTEM WHEN MOST OF THE DECISION TAKEN LONG TIME IN ADVANCE?

Second dimension "decision place": centric vs. autonomy questions to be answered.

WHAT IS THE LEVEL OF CORRELATION BETWEEN AUTONOMY AND CENTRIC PROCESSES?

AUTONOMY: WHERE?, WHEN? ARE SEGREGATED AIRSPACE STRUCTURES (UMAS/MAS) A SOLUTION?

WHAT IS THE LEVEL OF CORRELATION BETWEEN COMPLEXITY AND CENTRIC PROCESSES? ?

CENTRIC VS. AUTONOMY

DO TACTICAL DECISIONS IMPLY AUTONOMOUS AND FULLY AUTOMATED PROCESSES?

DOES STRATEGIC DECISION MAKING IMPLY CENTRIC SCENARIOS?

IN WHICH SCENARIO (CENTRIC OR AUTONOMOUS) WILL AUTOMATION PROVIDE HIGHER OVERALL SYSTEM PERFORMANCE?

IS HIGH TRAFFIC DENSITY/COMPLEXITY A KEY FACTOR LIMITING AUTONOMY?

Third dimension "best player": Human vs. automated player questions to be answered:

DOES UNCERTAINTY REQUIRE HUMAN CENTRED DECISION-MAKING?
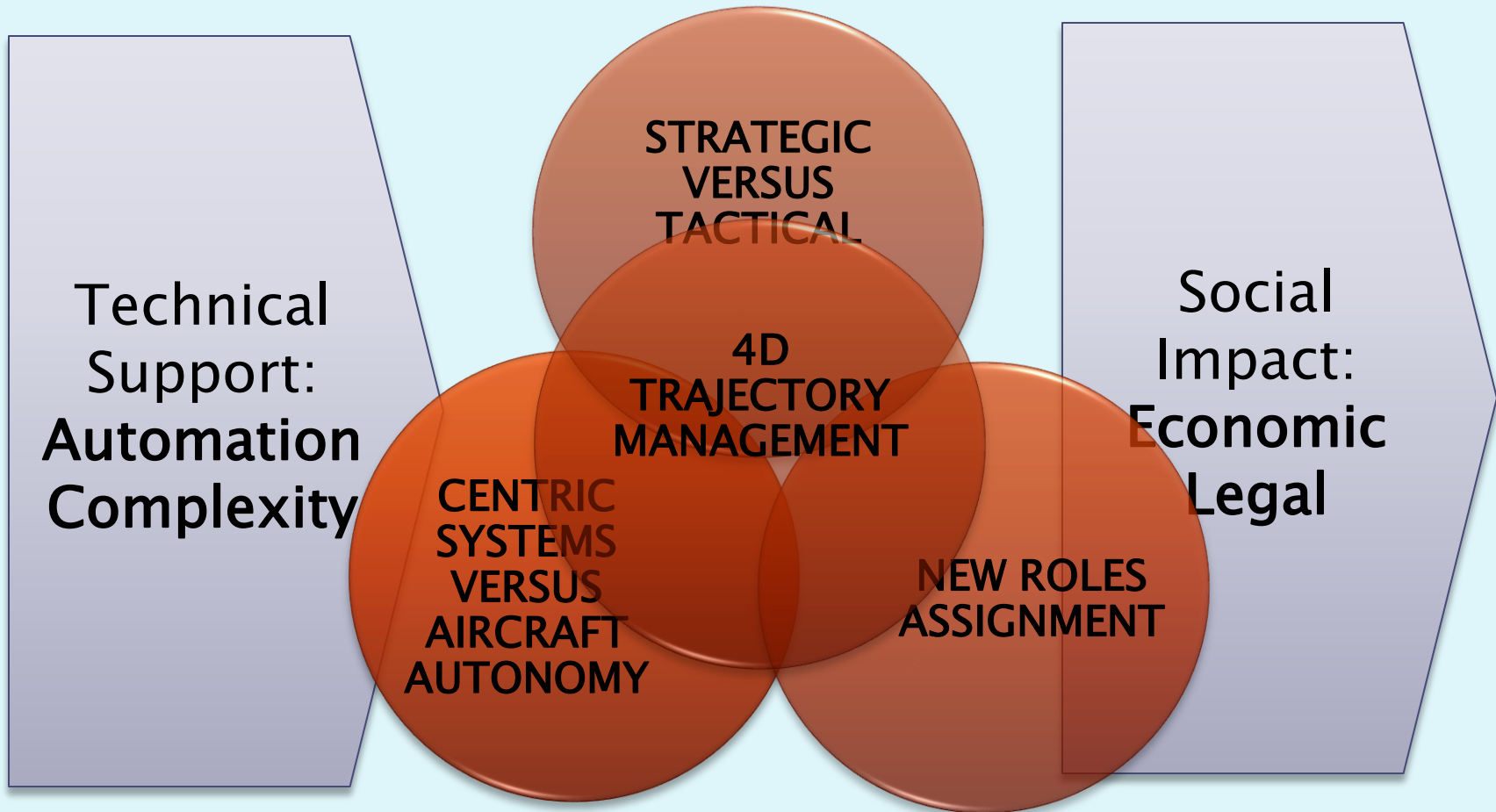
HUMAN VS. MACHINE

TO WHAT EXTENT DO STRATEGIC DECISIONS REQUIRE HUMAN INTENVENTION?

SHOULD 4D TRAJECTORY DECONFLICTION (EVEN TACTICAL DECISIONS) BE FULLY AUTOMATED?

The upper line: Imagination

▸ In broad sense the upper limit for innovation should only be limited by the human's imagination. Maintaining this principle; the resulting proposals have to be translated to the ATM context using open mind criteria. To transpose any of these innovative initiatives to the ATM context some "as realistic as needed" a set of analysis and/or trials have to be developed.

ATM main research areas

Technical Support: **Automation Complexity**

STRATEGIC VERSUS TACTICAL

4D TRAJECTORY MANAGEMENT

CENTRIC SYSTEMS VERSUS AIRCRAFT AUTONOMY

NEW ROLES ASSIGNMENT

Social Impact: **Economic Legal**

Conclusions

- Legacy in ATM limits the vision that could take advantage of the available technology.
- Long term ATM changes should be based on the overall system performance.
- The vision shall be that ATM is mainly related to 4D trajectories management, involving invariant processes.
- Based on 4D trajectories management, research areas must be oriented to find out the best answer to these three main questions:
  - **Strategic versus tactical?,**
  - **Centric systems versus aircraft autonomy? and**
  - **New roles assignment?**