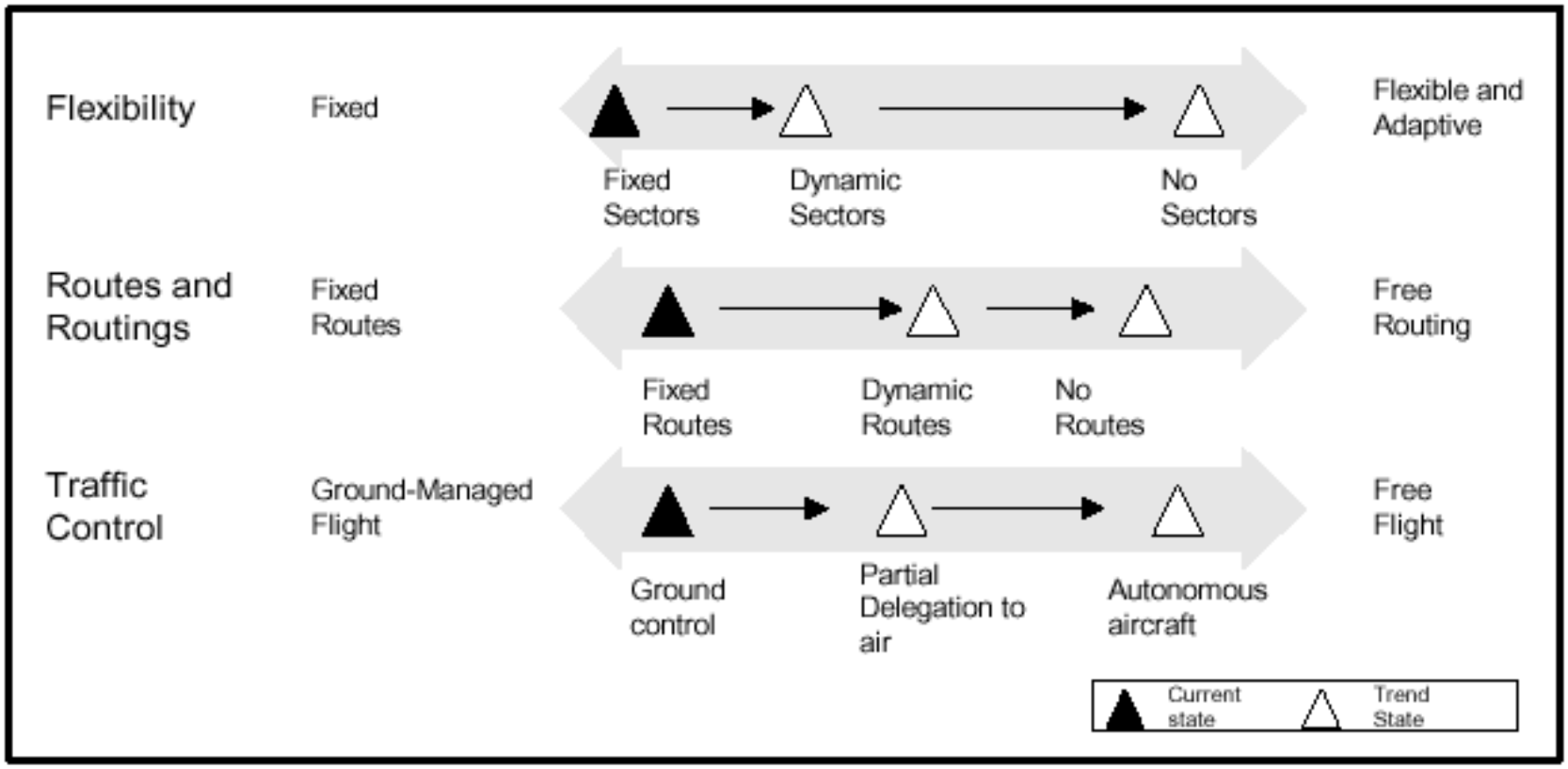
Free Flight

JM Alliot

Sources : FAA / Eurocontrol / CENA

OCD(Europe)


Flexibility
Fixed
Flexible and Adaptive
Fixed Sectors
Dynamic Sectors
No Sectors
Routes and Routings
Fixed Routes
Free Routing
Fixed Routes
Dynamic Routes
No Routes
Traffic Control
Ground-Managed Flight
Free Flight
Ground control
Partial Delegation to air
Autonomous aircraft
Current state
Trend State

NAS(USA)

- National Airspace modernization plan
- The main objective of NAS modernization is moving the NAS towards a new type of operating environment known as Free Flight as defined by RTCA.

RTCA

- Organized in 1935 as the Radio Technical Commission for Aeronautics,
- Not-for-profit corporation that develops consensus-based recommendations
- Recommendations used by the Federal Aviation Administration (FAA) as the basis for policy, program, and regulatory decisions and
- Recommendations used by the private sector as the basis for development, investment, and other business decisions.
- Includes over 200 government, industry, and academic organizations.

Free Flight NAS/RTCA definition

- A safe and efficient operating capability under instrument flight rules in which the operators have the freedom to select their paths and speed in real time. Air Traffic restrictions are imposed only to ensure separation, to preclude exceeding airport capability, to prevent unauthorized flights through special use of airspace, and to ensure safet of flights. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a step toward Free Flight.

Free Flight

- One word / many different concepts :
  - Free Route
  - Free Flight / centralized control
  - Free Flight / Autonomous Aircraft

Free Route

- No more Standard Routing Scheme
- Aircraft can freely choose their route, but still fly from waypoint to waypoint

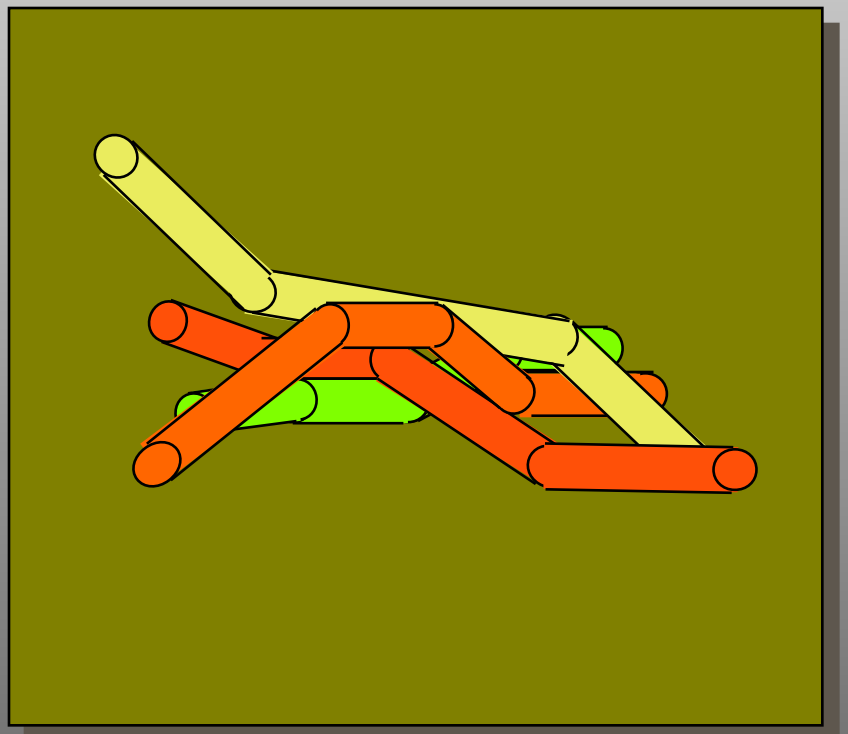
ICARUS and the mechanical bird

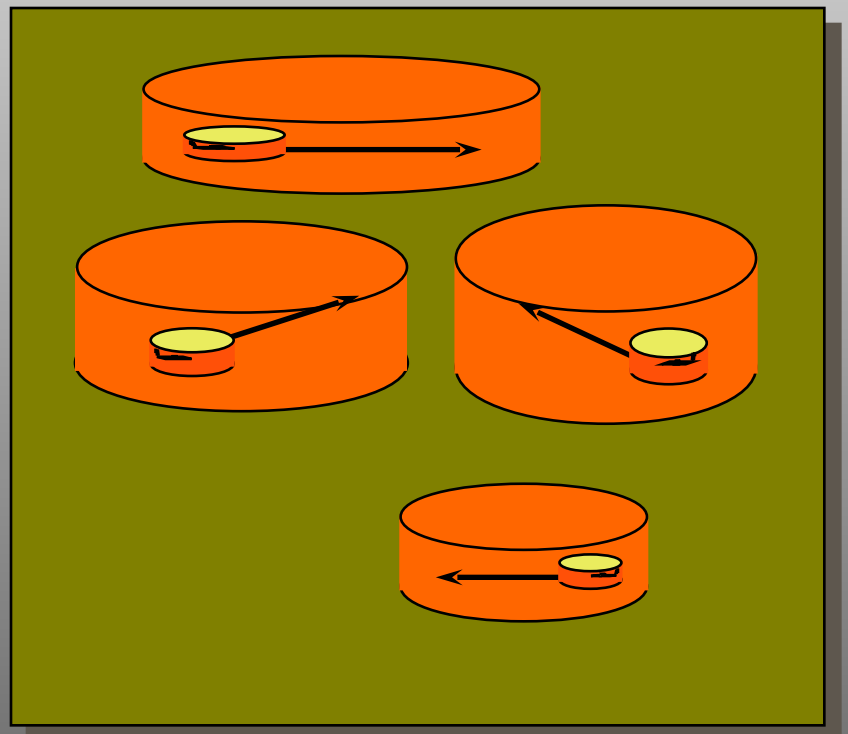
Source : Face à l'automate Alain Gras et al.

- ICARUS
  - Pilot sees and is aware of his environmentv - He chooses his flightpath : route, flight level, and speed
  - Pilot maintains separation

- Mechanical bird
  - Flightpath : routes, flight level, time are dictated by the ground
  - separations are maintained by ground

Tubes 4D and Free Flight





Free Flight / Centralized control

- Planes can take a direct route from origin to destination
- Responsability of control remains on the ground

Centralized control / Ancestors

- AERA III :
  - US 1980, FAA / MITRE Corporation
  - Automatic Control with extremely primitive solvers (Gentle-Strict algorithm)
- ARC 2000 :
  - Eurocontrol, 1990
  - Automatic control with 4D tubes
  - Solvers based on the rubber band algorithm, a multi-local optimization algorithm

Free Flight / Autonomous Aircraft

- Planes can take a direct route from origin to destination
- Planes have to maintain separation themselves

Autonomous Aircraft / Ancestors

- VFR rules
- ACAS / ASAS concept : 1950 !
- TCAS : 1981

ACAS

- Self contained system, independent of ground-based system. Provides advice to pilots on potential conflicting, transponding traffic.
- ACAS is the ICAO, *generic term* for the Airborne Collision Avoidance System based on secondary surveillance radar (SSR) transponder signals
- Operates independently of ground based equipment.

ACAS

- ACAS I : utilises interrogations of, and replies from, airborne radar beacon transponders. Provides Traffic Advisories (TAs) only.
- ACAS II : ACAS I + Resolution Advisories (RAs) in the vertical plane.
- ACAS III : ACAS II + Resolution Advisories in the horizontal plane.

TCAS

- Traffic Alert And Collision Avoidance System
- US commercial (and only) implementation of the ACAS concept
- TCAS I : implements ACAS I
- TCAS II : implements ACAS II
- TCAS III : development has ceased
- TCAS IV : should implement ACAS III. Development in stasis.

TCAS

- TCAS II v7 complies with the ICAO ACAS II standards
- Mandatory for all civil fixed-wing turbine-engined aircraft with mass > 15t or more than 30 passenger seats since 1/1/2000
- Will be mandatory for all civil fixed-wing turbine-engined aircraft with mass > 5.7t or more than 19 passengers seats the 1/1/2005

ACAS not so well-known facts

- Non-transponding aircraft, and aircraft equipped with non-altitude reporting transponders, are not detected by an ACAS
- ACAS cannot resolve all possible collisions and may even cause some risk of collision
- Performance of ACAS depends on the design and management of the airspace

ACAS Fundamental Principle

- ACAS is not intended to replace the functions of the air traffic controller and the provision of separation between aircraft, operating in compliance with air traffic control clearances, remains the primary responsibility of air traffic control.

The Free-R project

- 1996/1998 : Autonomous aircraft with Extended Flying Rules (EFR), an extension of Visual Flying Rules
- Problem : EFR was not able to solve multiple conflicts situations
- 1998-> now : Limited Delegation Concept. Free Flight is postponed until 2015 (?)

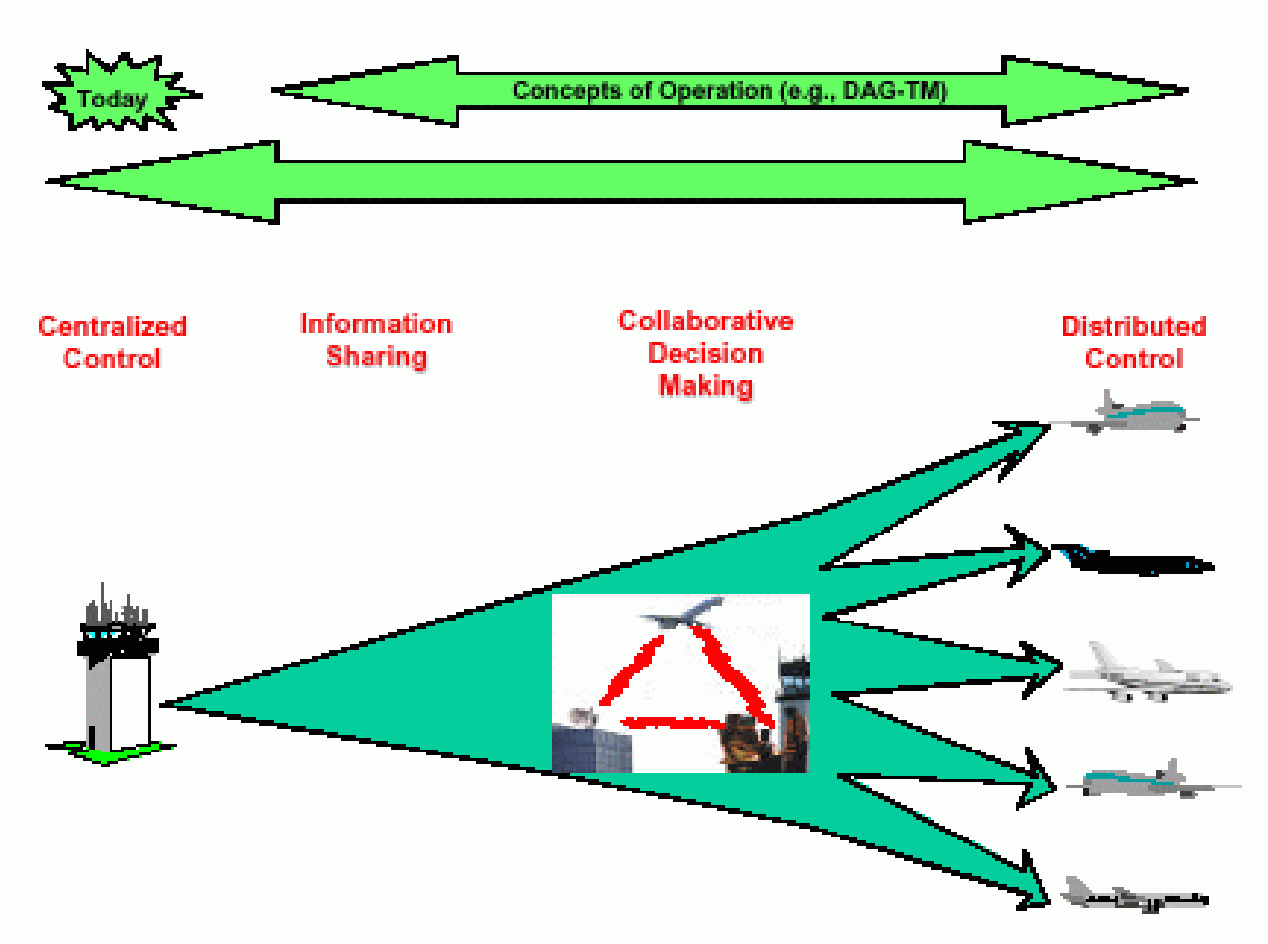
Limited Delegation

- The controler delegates to the pilot some tasks related to separation assurance.
- Target : near term applications (2005)
- Goals : reduction of the controler workload
- Limited delegation is NOT related to (and will not implement) Free Routing or Free Flight.

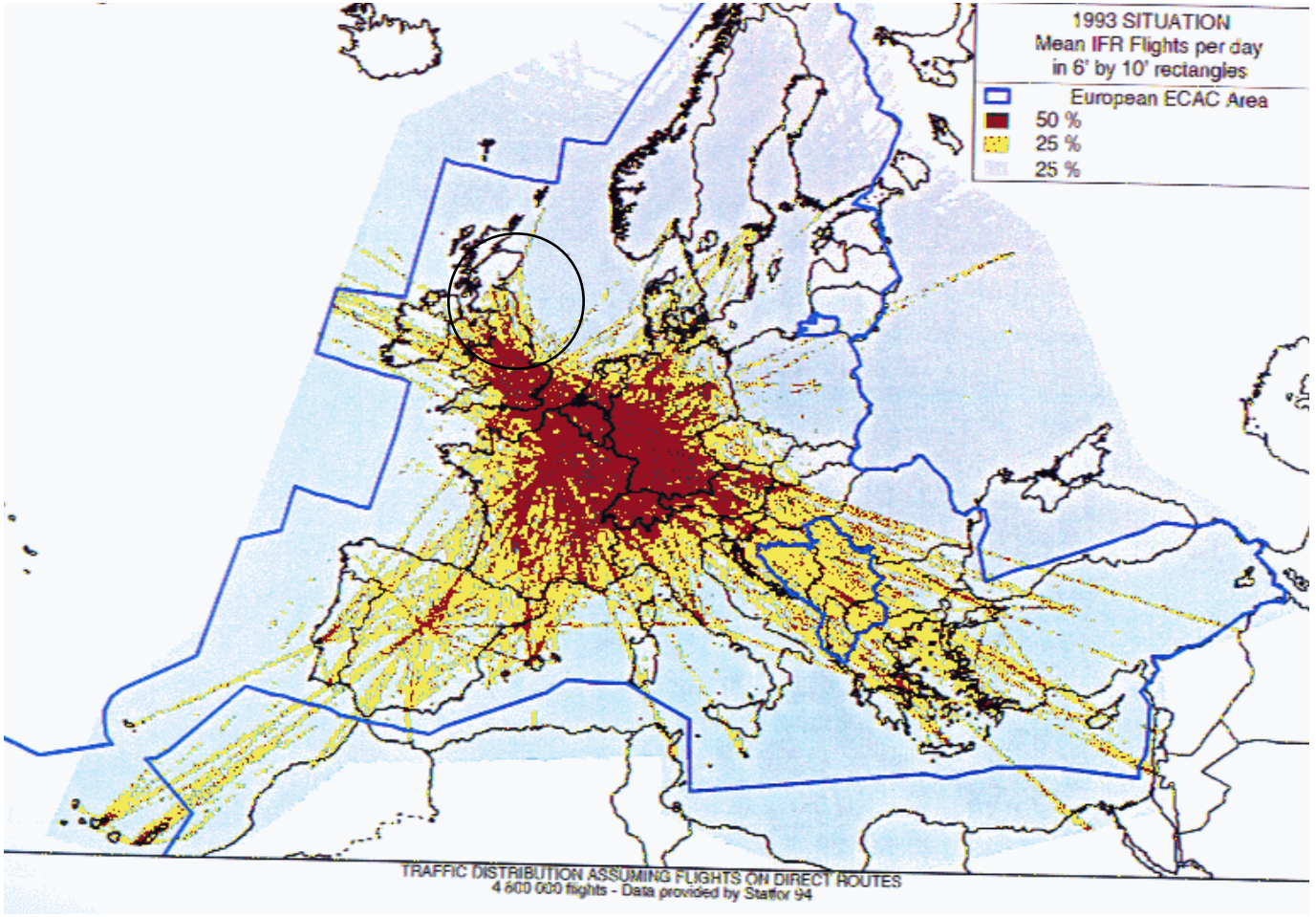
NASA DAG/TM

- DAG/TM : Distributed Air Ground Traffic Management
- NASA concept
- Discusses lot of different issues, but does not present any single algorithm to implement safely the concepts presented

NASA DAG/TM


Today
Concepts of Operation (e.g., DAG-TM)
Centralized Control
Information Sharing
Collaborative Decision Making
Distributed Control

Trafic density in Europe



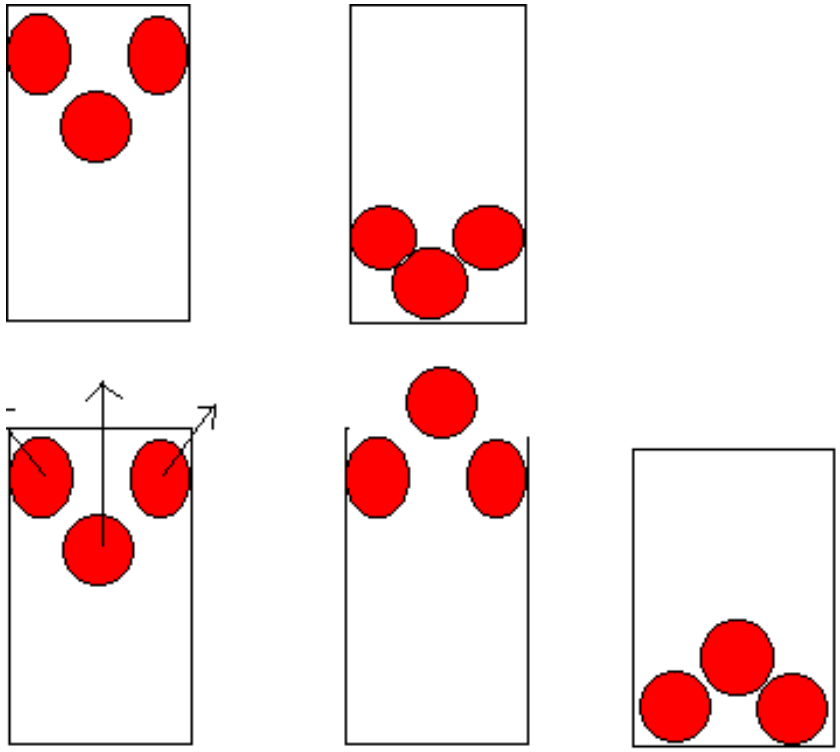
200 NM

From VFR to Free Flight

Separation mode	Freedom	Capacity Density	Technology
VFR	***	**	0
rocedures	0	0	*
RADAR	*	*	*
ASAS	**	**?	**
4D Tubes	*	***?	***
Free Flight	***	**?	***

Misconception : global and local optimization

- Many local optima don’t make a global optimum



Autonomous Aircraft / Ideology?

Simulations results

- Free Routing : reduction of 5 to 10% max of fuel burning and route length
- Autonomous aircraft : short term solution, inefficient in high density area, less capacitive than organized traffic