Human-Systems Integration: From Automation to Tangible Interactive Systems

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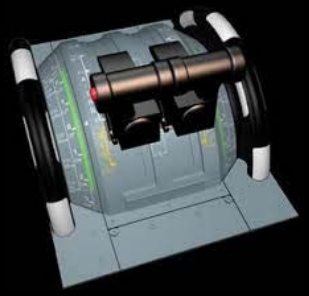
Fellow of the Air and Space Academy

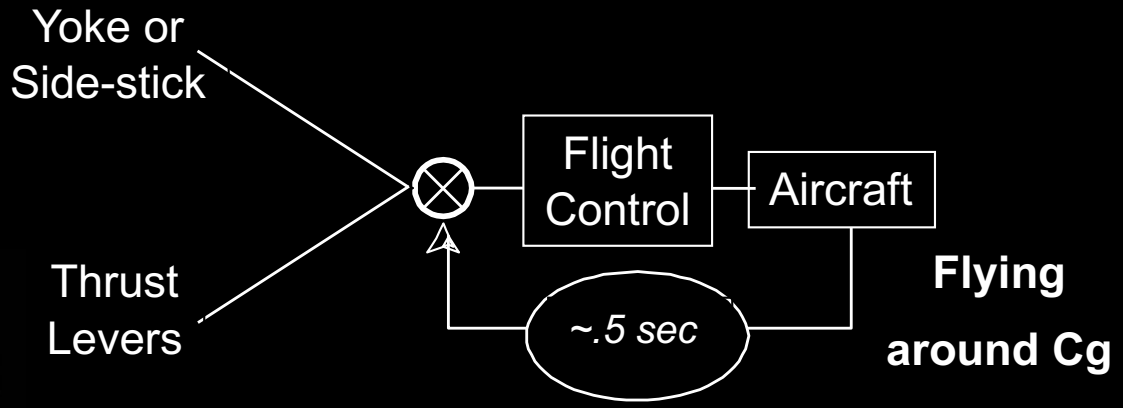
A Distinction…

– Automation

– Human-Machine Interface

Loop 1: Trajectory Control Automation

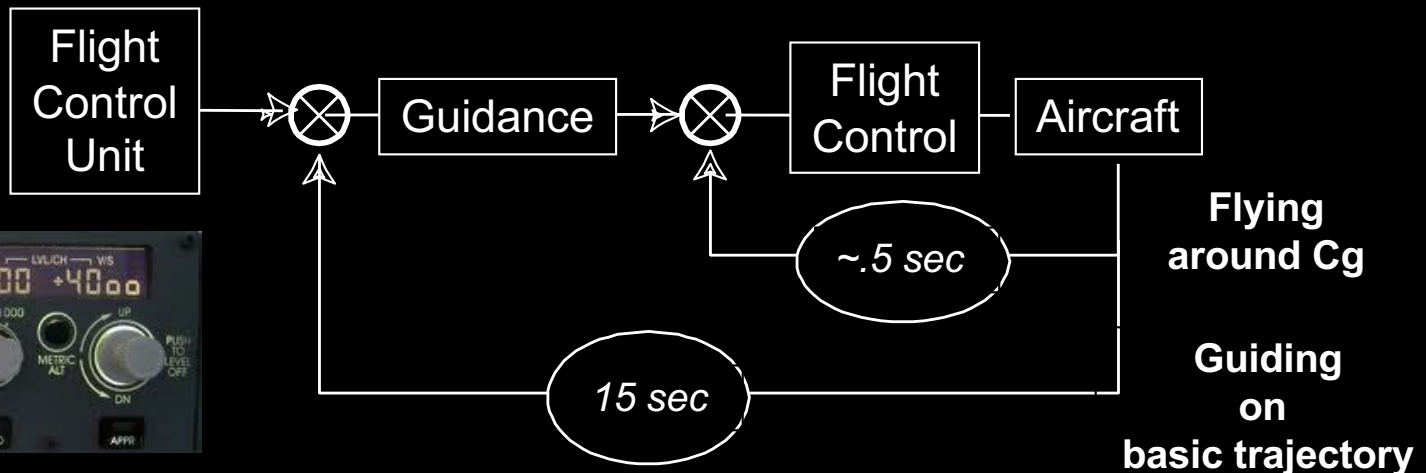




- Single agent
- One parameter at a time

The 4-loop approach to ATM was first provided by Etienne Tarnovski at HCI-Aero'06, Seattle, USA

Loop 2: Guidance Automation

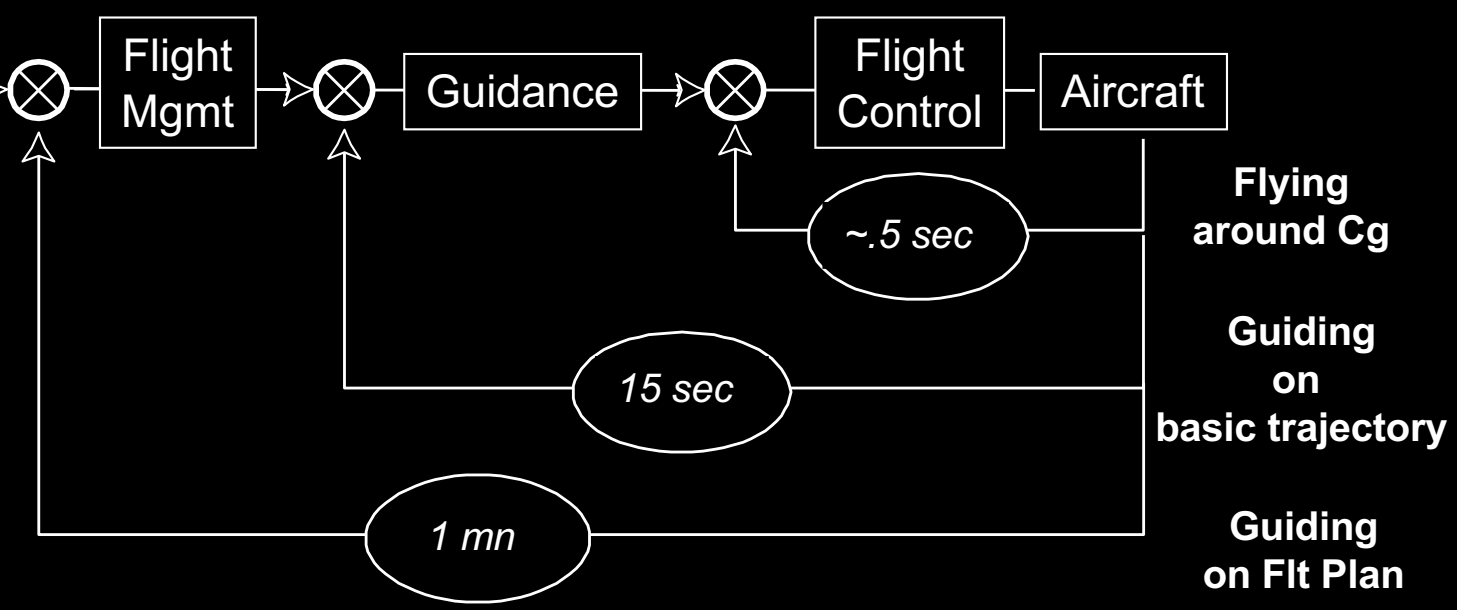


- Integrated and digital autopilot and autothrottle
- High level modes (evolution)

Loop 3: Navigation Automation

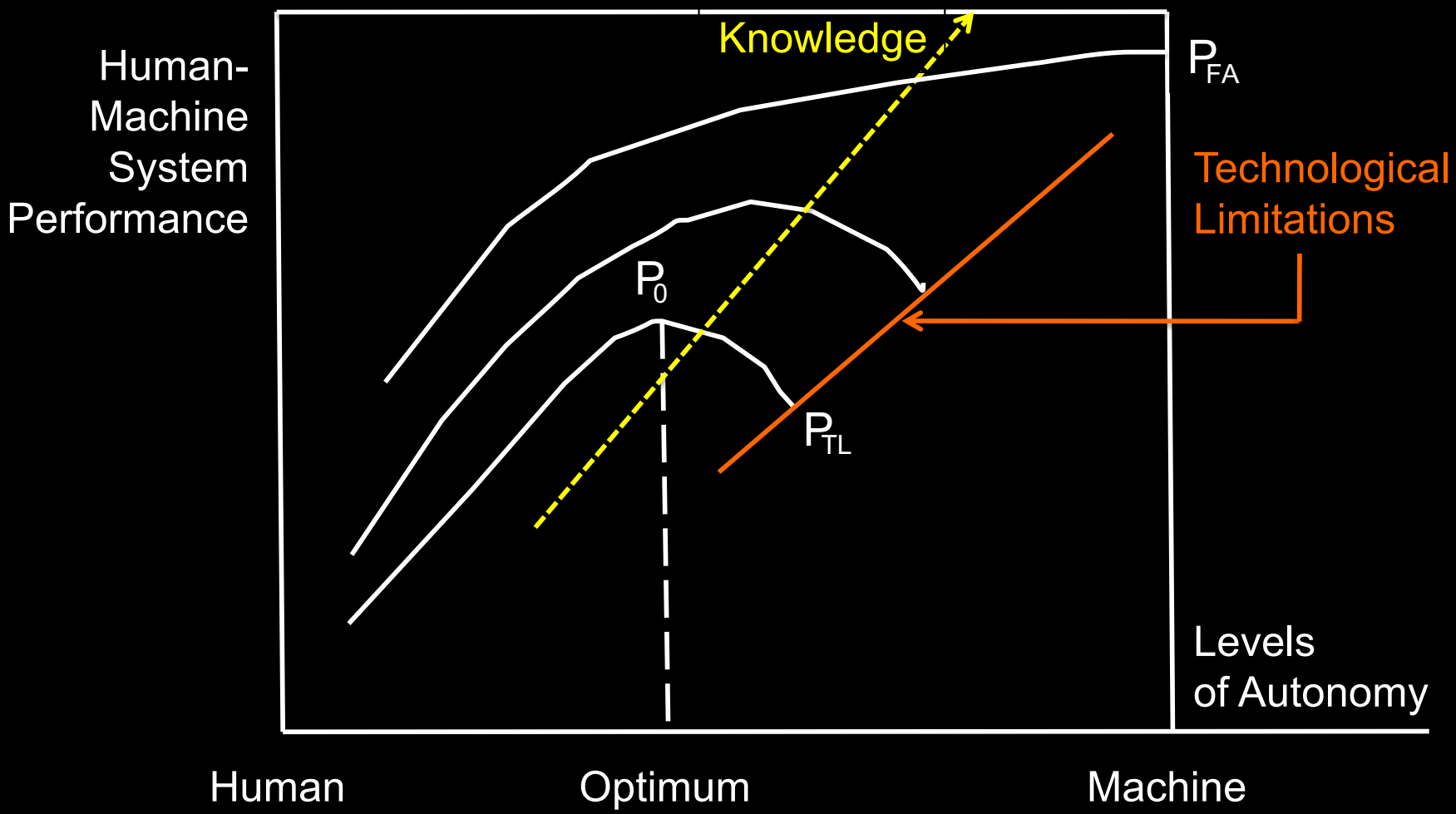
Glass cockpits

FMS: Flight Management System
CDU: Control and Display Unit



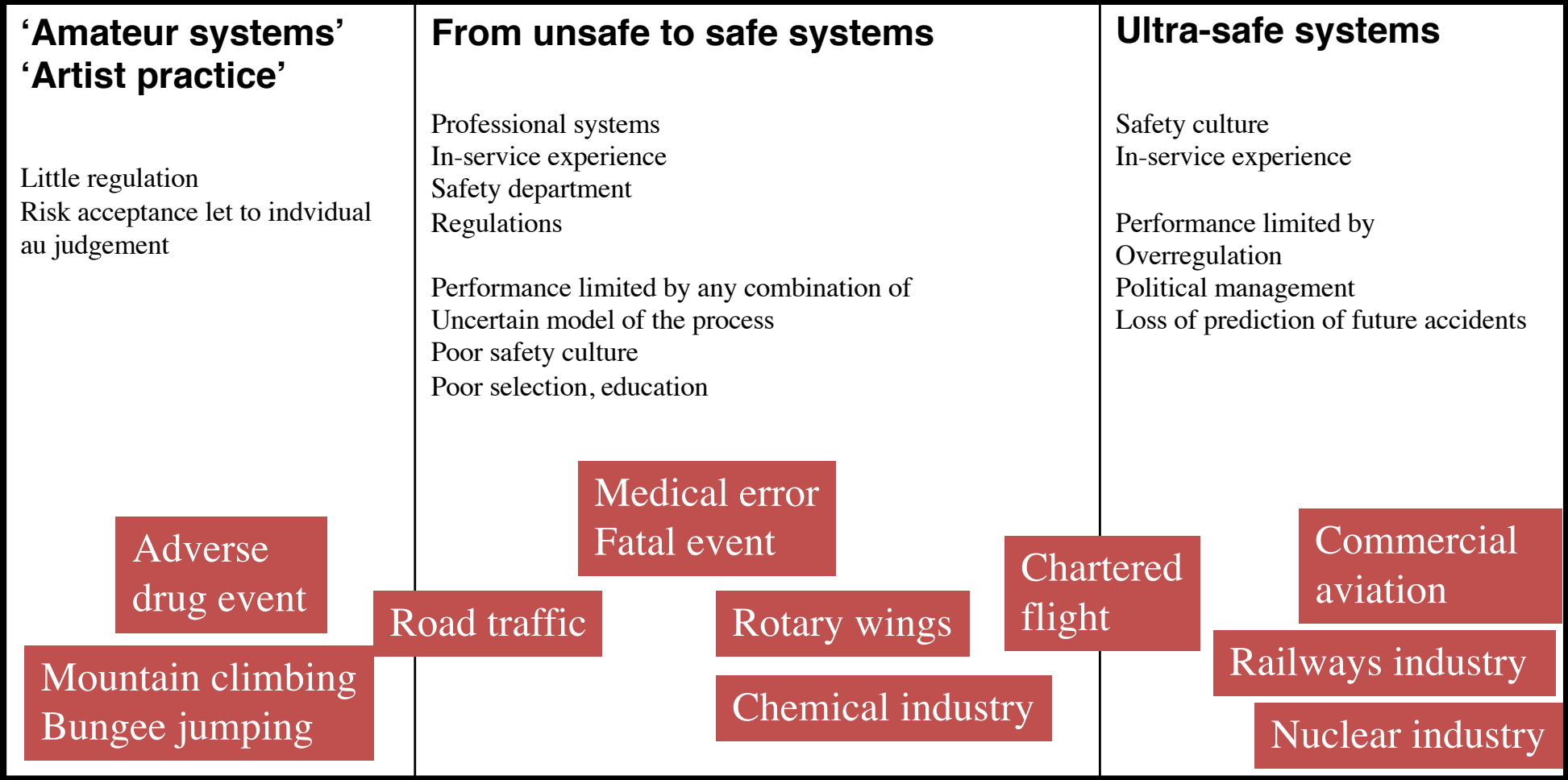
- Integration of guidance and flight management
- From control to management (1st revolution)

Automation / Autonomy Diagram



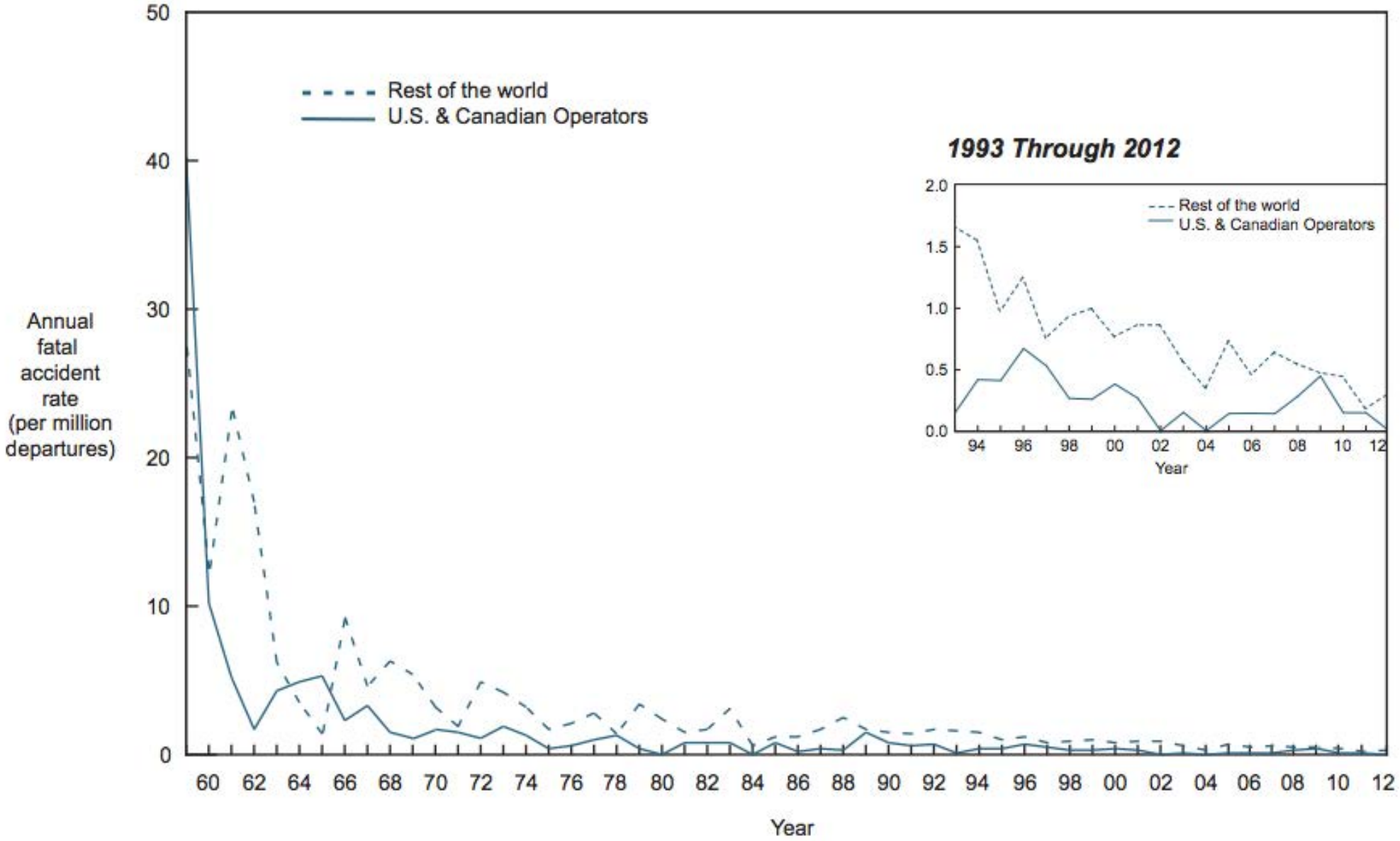
Safety-Critical System Categories

(from Amalberti, 2001)



U.S. and Canadian Operators Accident Rates by Year

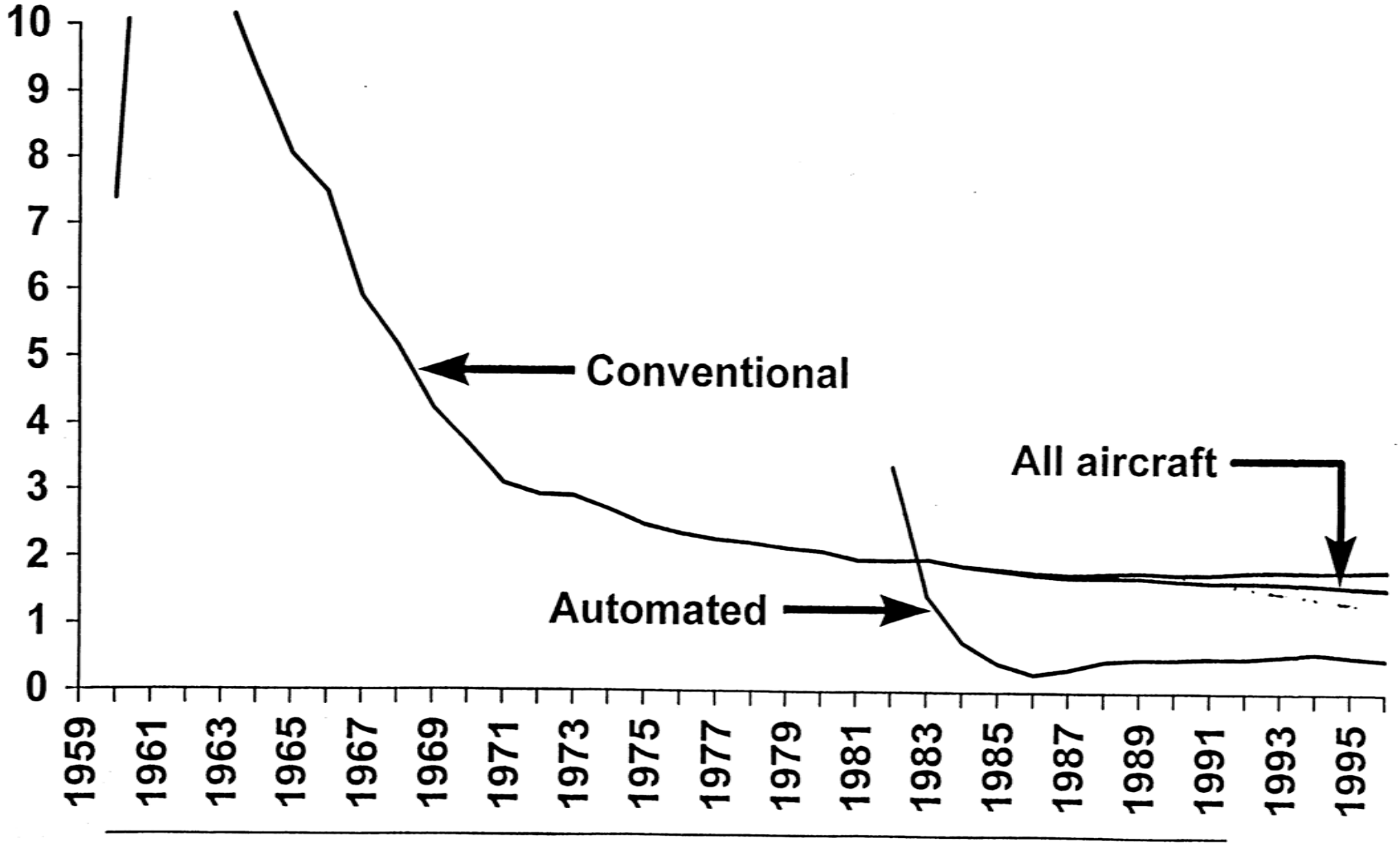
Fatal Accidents – Worldwide Commercial Jet Fleet – 1959 Through 2012



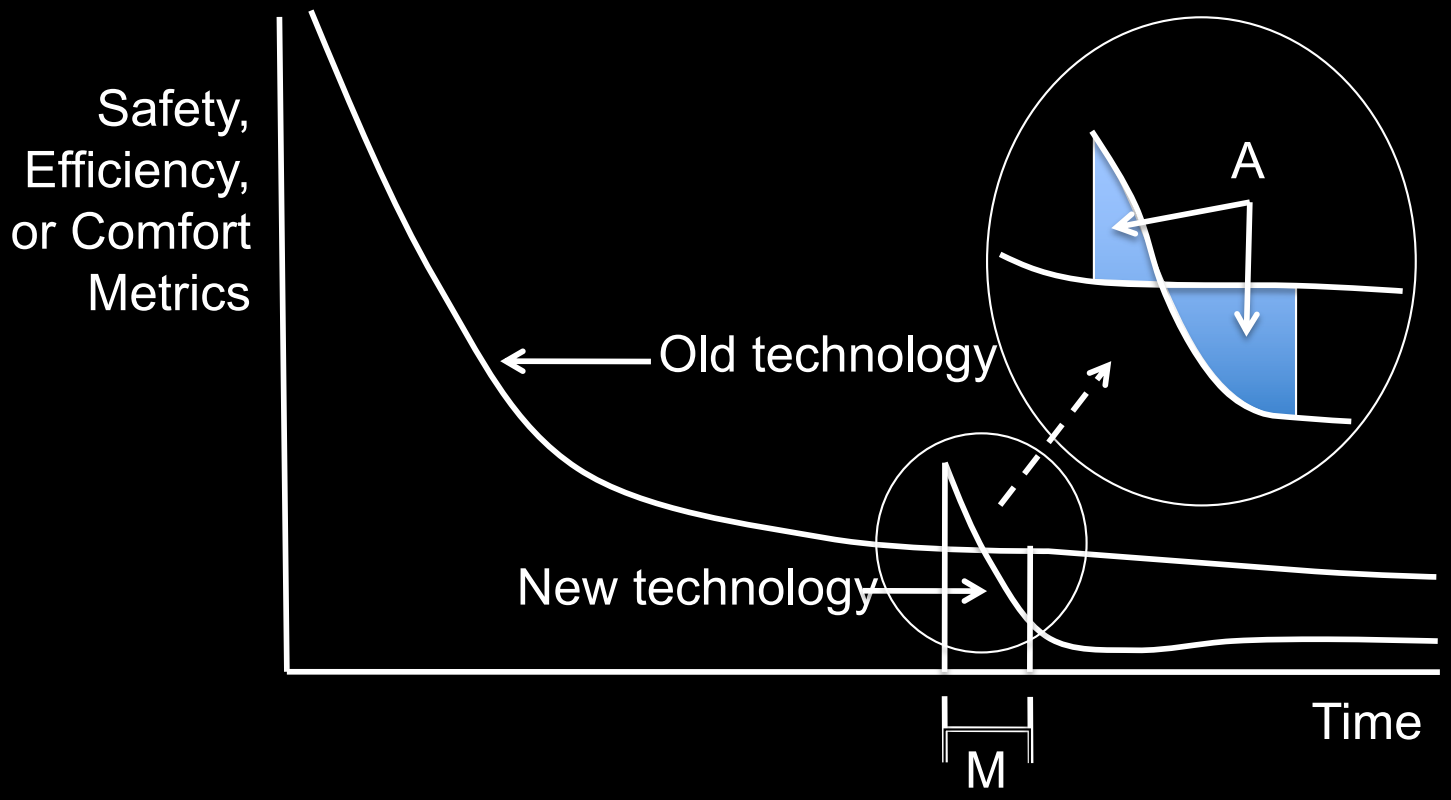
All Automated vs. All Conventional

Fourth Flight Safety Conference

Hull loss per million departures

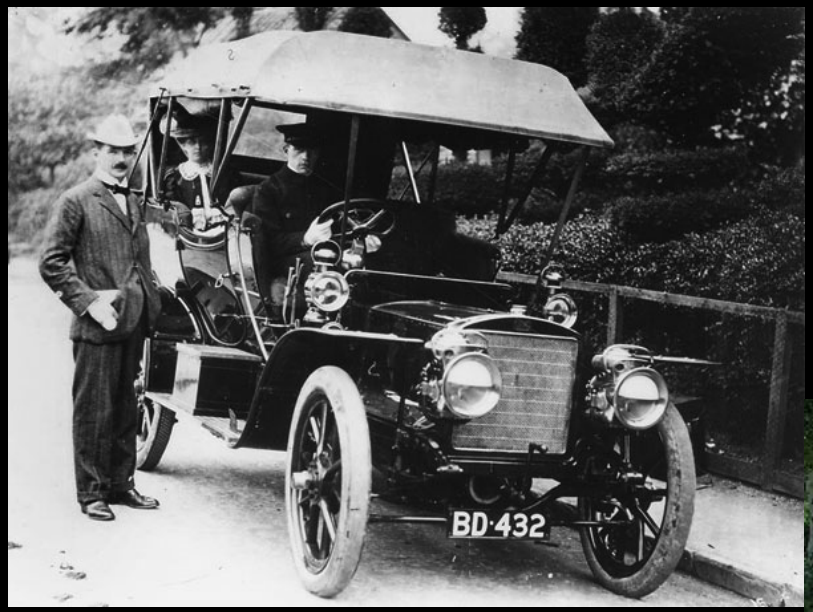


Safety Maturity Curves



M: Maturity period
A: Acceptability area

Where is the Difference?



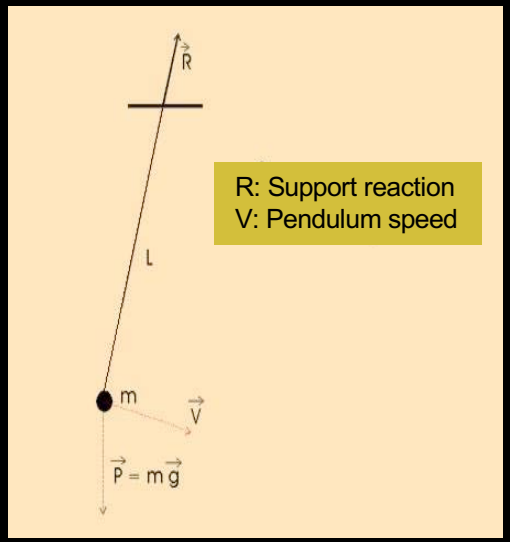
Maturity
of Technology

Maturity
of Practice

Automation can be Good…

… if it is human-centered:

- Situation awareness and decision-making
- Flexibility → Appropriate function allocation
- Error management support
- Cognitive stability

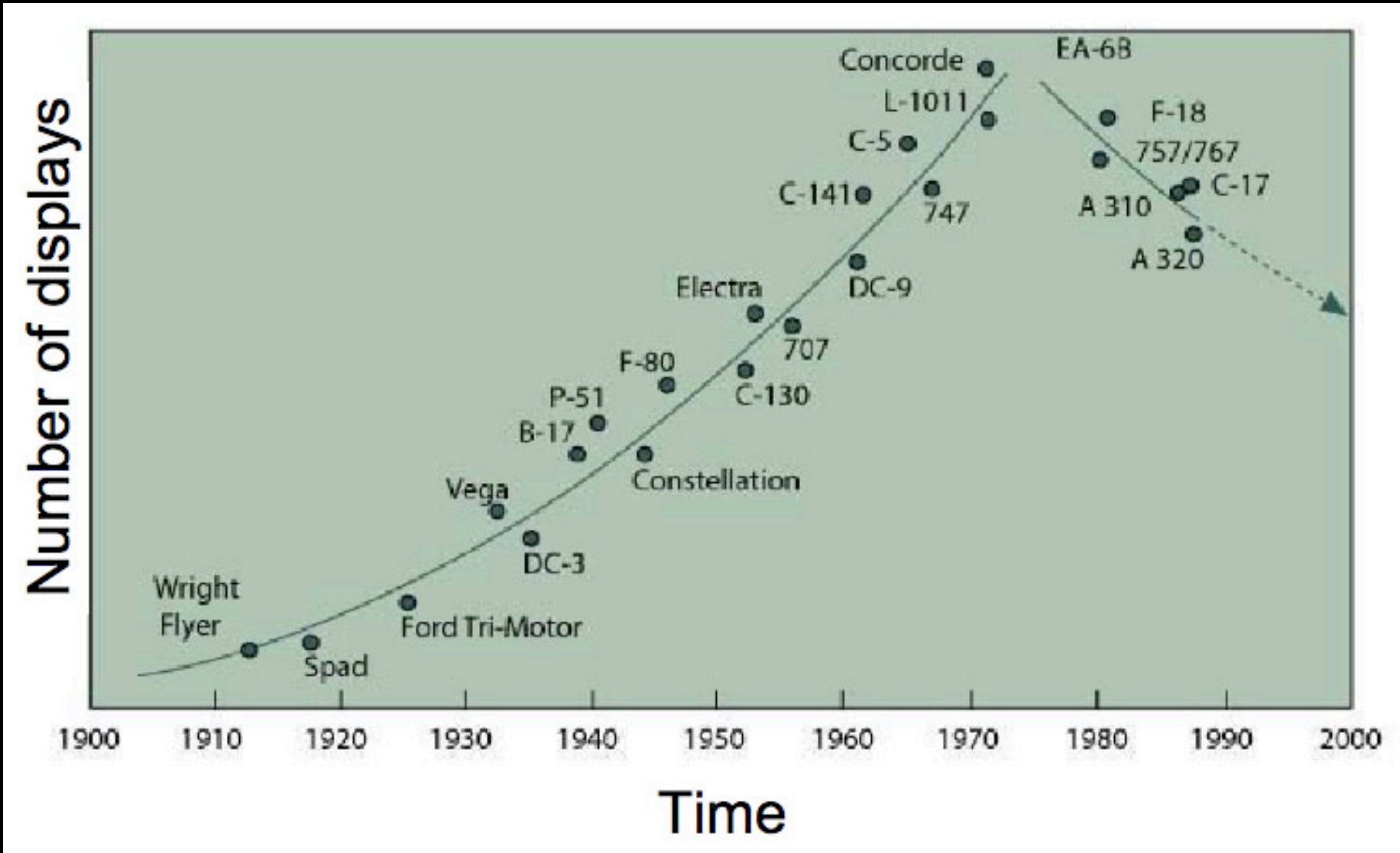


A Distinction…

– Automation

– Human-Machine Interface

Number of displays in cockpits



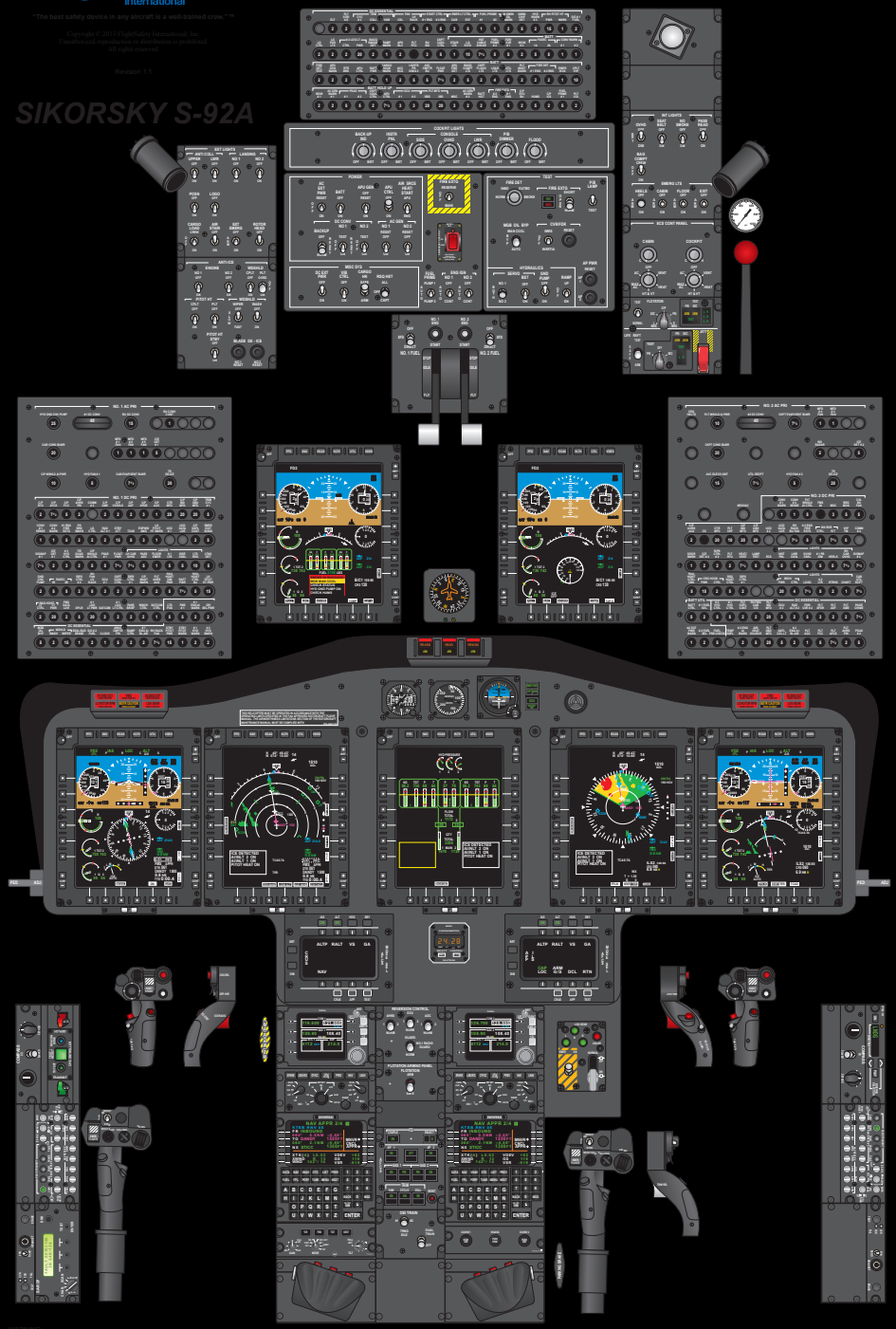
FlightSafety
international

"The best safety device in any aircraft is a well-trained crew."

Revision 1.1

SIKORSKY S-92A

Managing complexity

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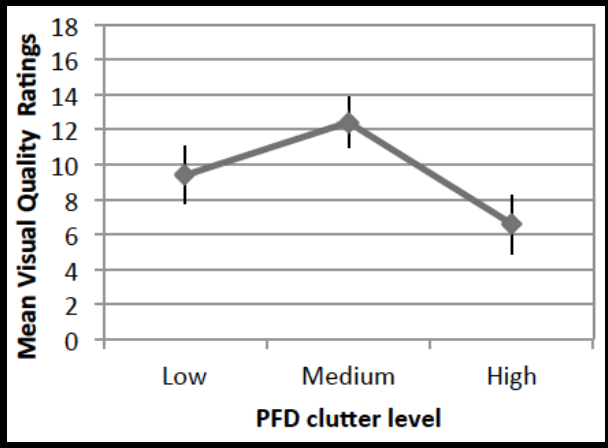
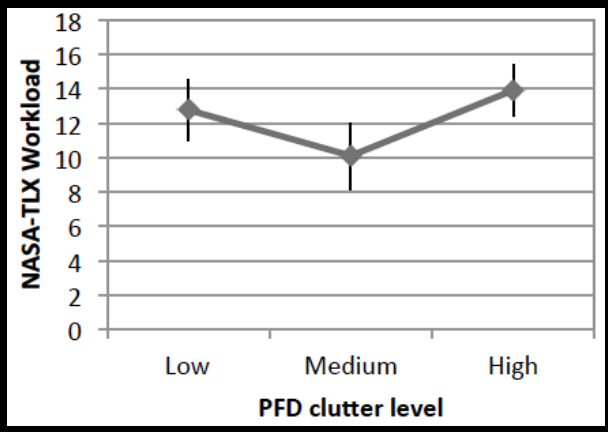
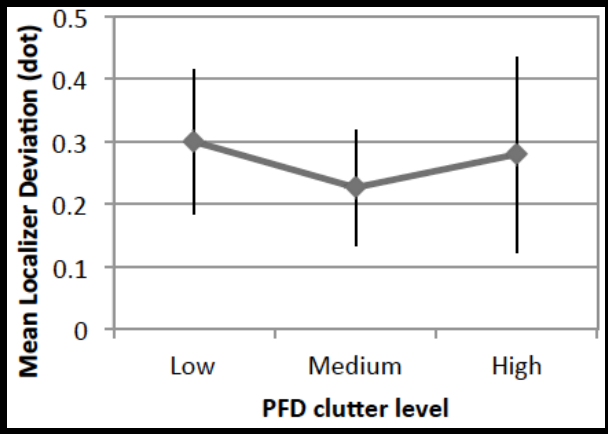
I-PTFB
Managing complexity

high-clutter







(Doyon-Poulin et al., 2014)

Managing Complexity

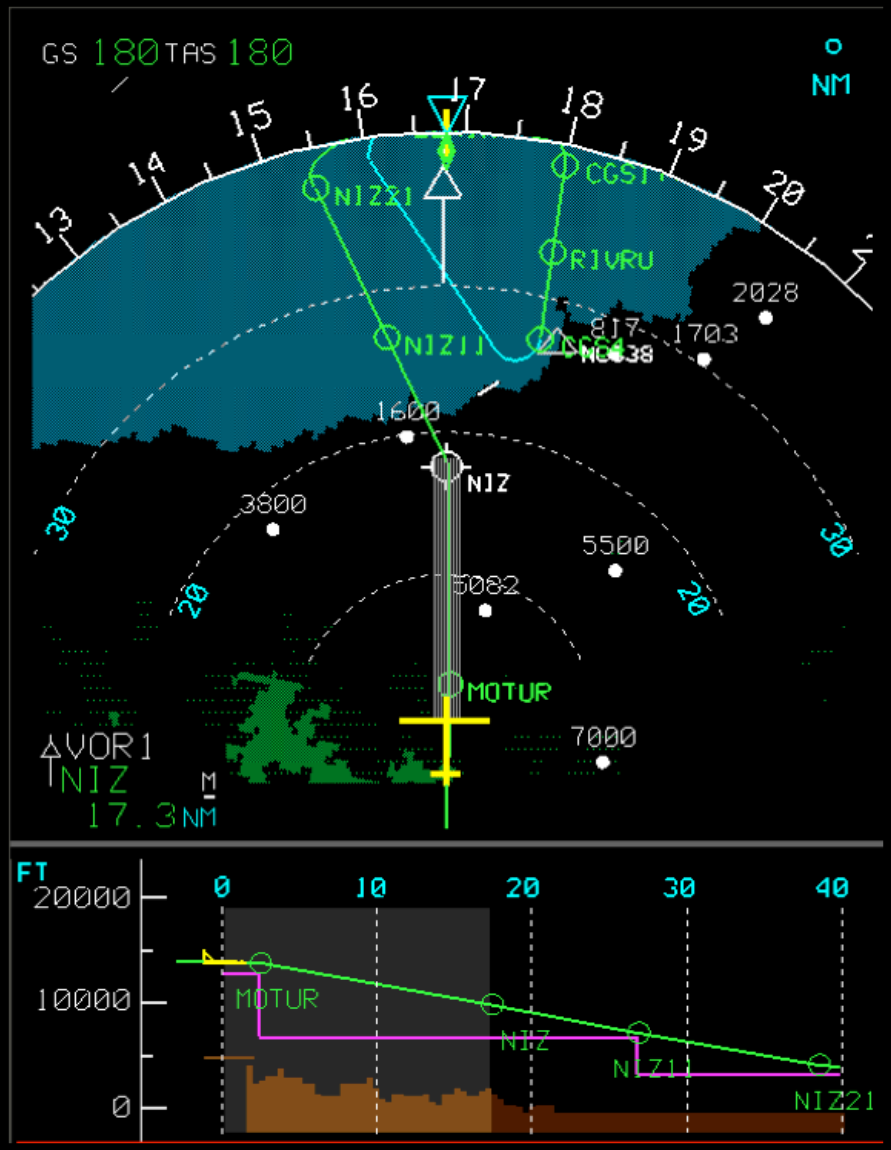
Situation awareness
Decision-making
Risk management

Automation vs. flexibility
Linear vs. non-linear
Cognitive model

Solutions

Participatory design
Integration
Test, test, test…
Maturity
Training → Familiarity
Change management

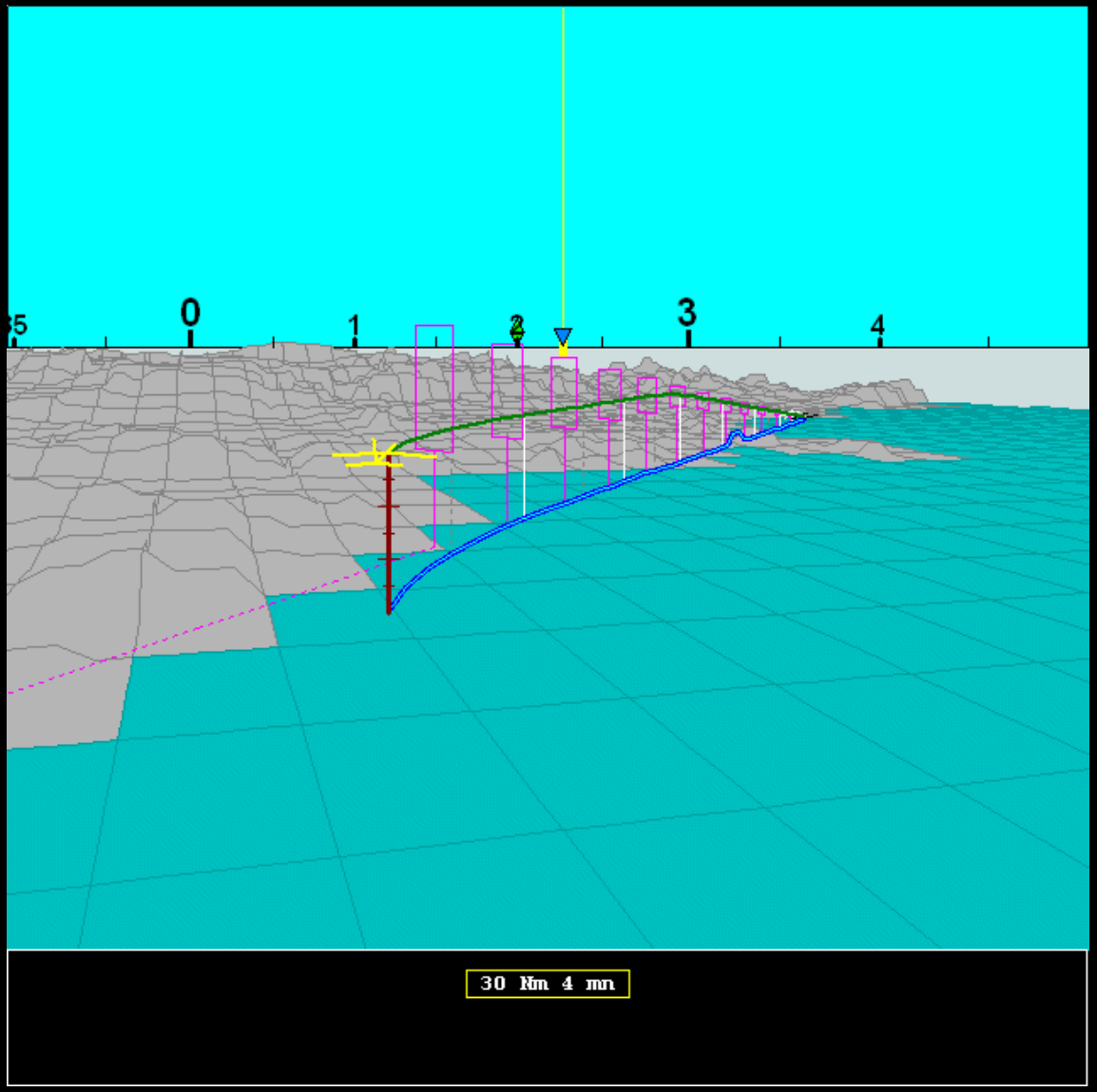
Vertical Display



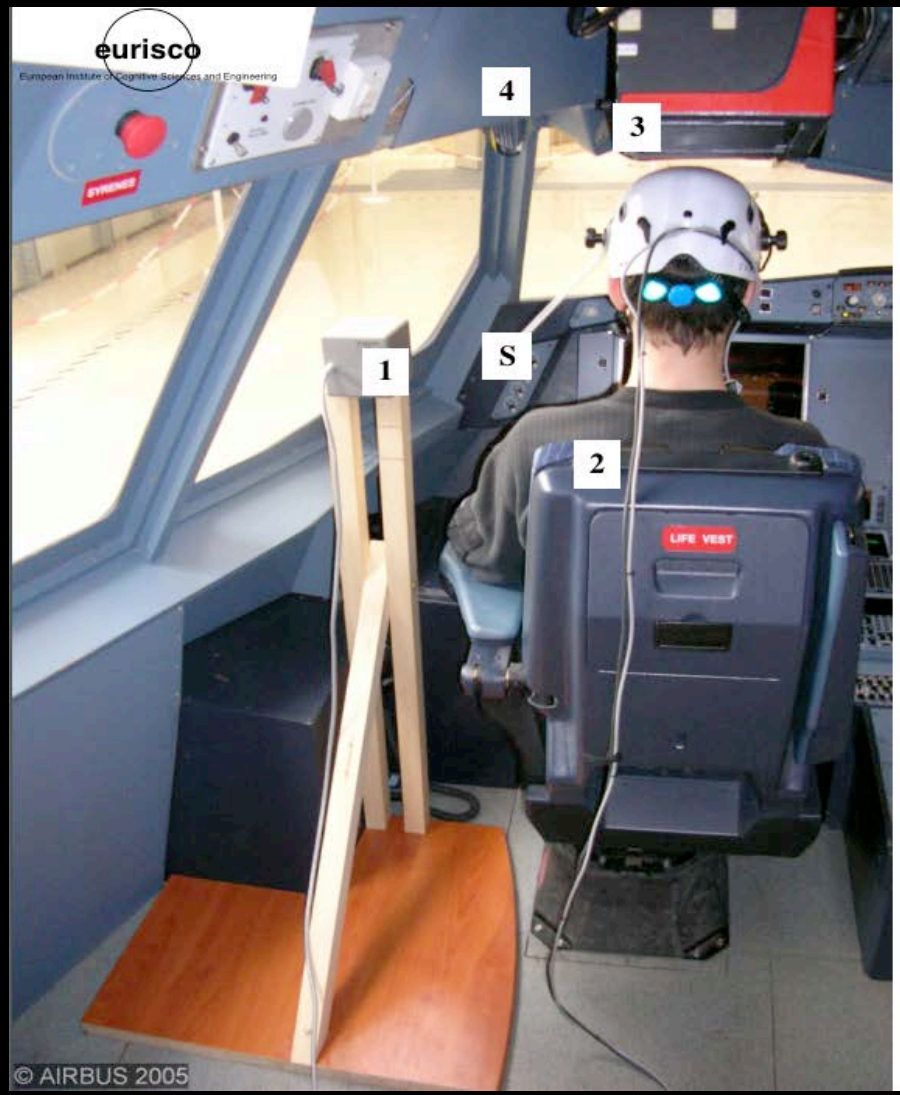
DIVA project (1998-2001)

- Provides superior flight crew awareness with a graphical view of vertical plan
- Trend vector predicts vertical path relative to terrain and waypoint constraints
- Enhancements include display of the vertical navigation profile
- Stabilized approaches through better energy awareness

3D Navigation Display



Measuring SA with Eye Tracking



Distances between the head sensor S and:
- the magnetic field generator 1
- the surrounding metallic surfaces 2, 3, 4

Note: **3** is the HUD box

Distances are given in centimeters

Option 1: Narrow Angle stick

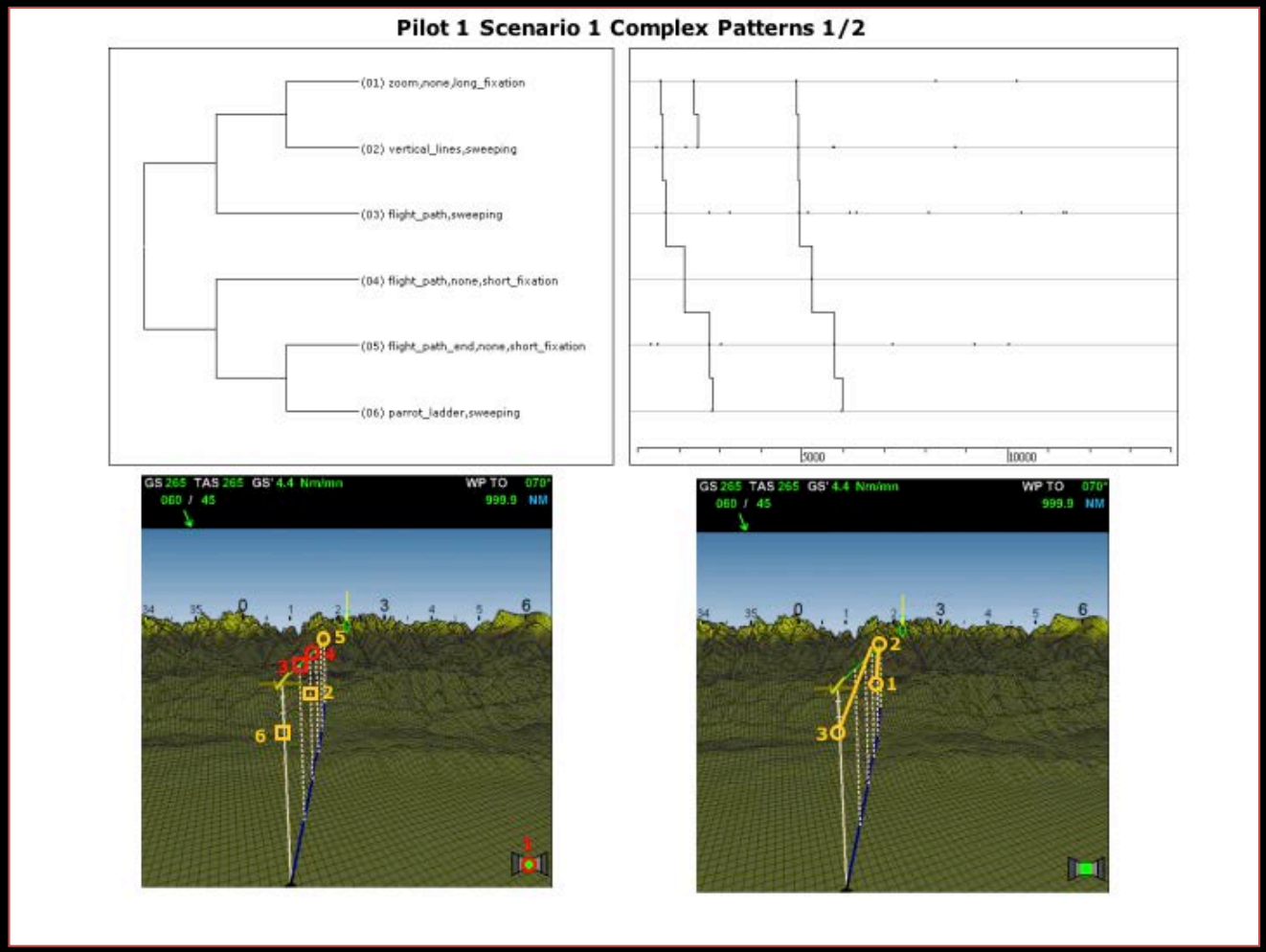
Gaze	*Straight*	*Right*	*Left*
S-1	22	26	35
S-2	30	40	10
S-3	36	33	30
S-4	32	35	32

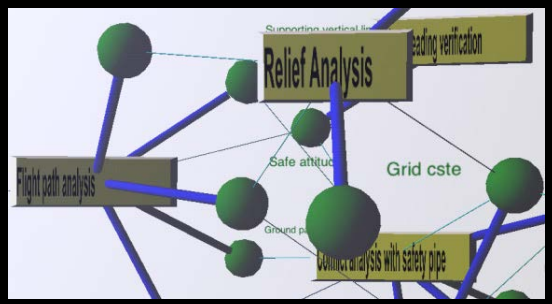
Option 2: Wide Angle stick

Gaze	*Straight*	*Right*	*Left*
S-1	21	26	31
S-2	26	37	9
S-3	37	35	34
S-4	35	36	31

eurisco
European Institute of Cognitive Sciences and Engineering

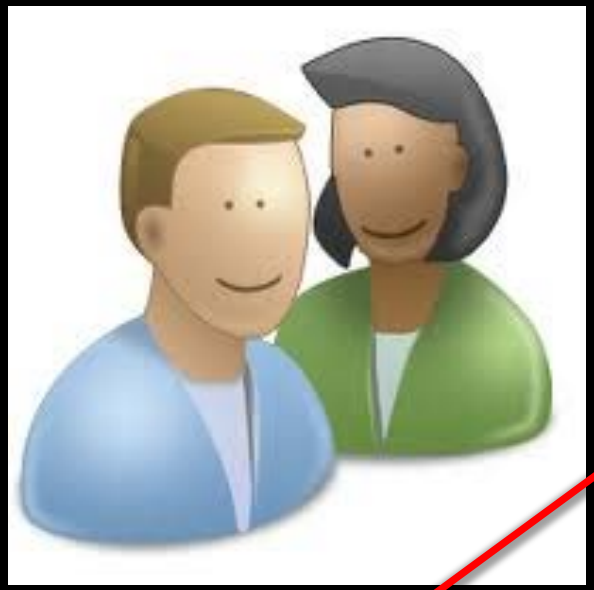
Measuring SA with Eye Tracking

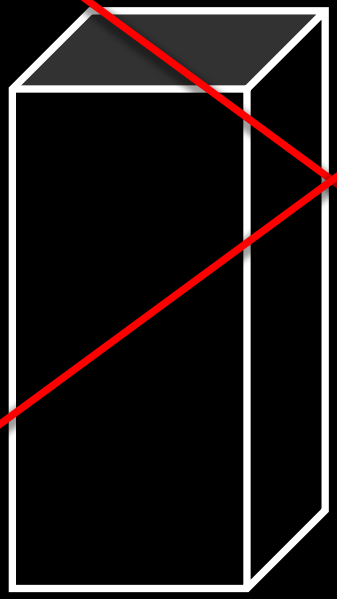


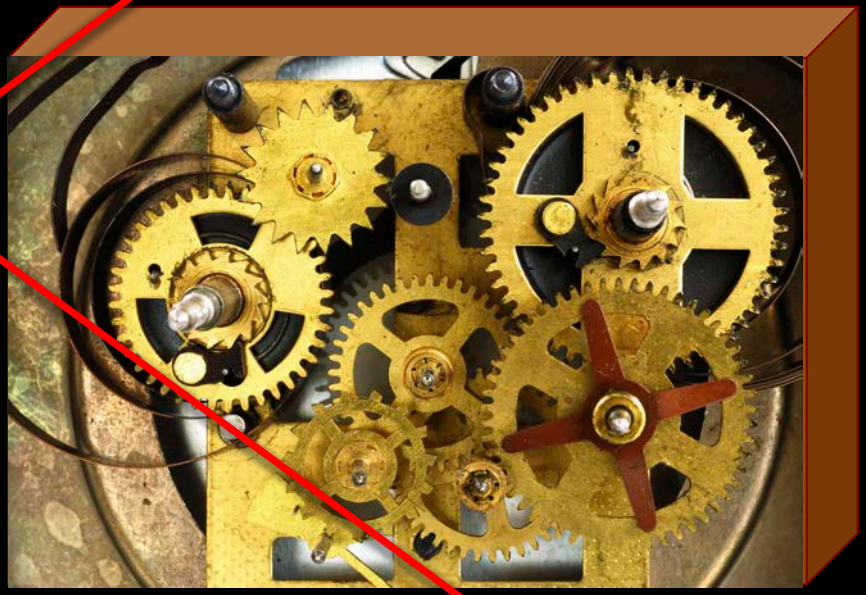


What did we do so far?

User Interface







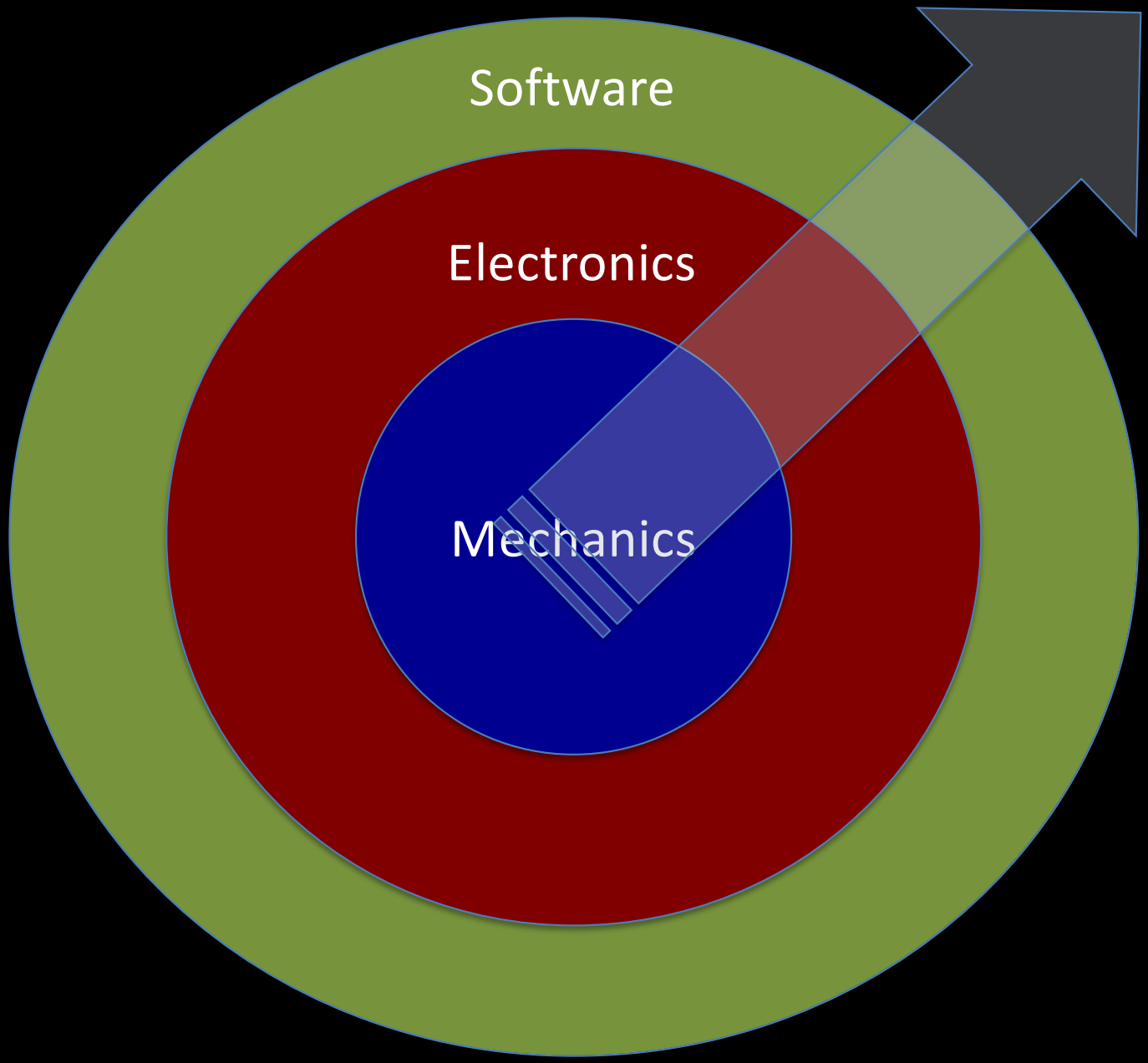
Human Factors

Ergonomics + Automation

Engineering

20th century

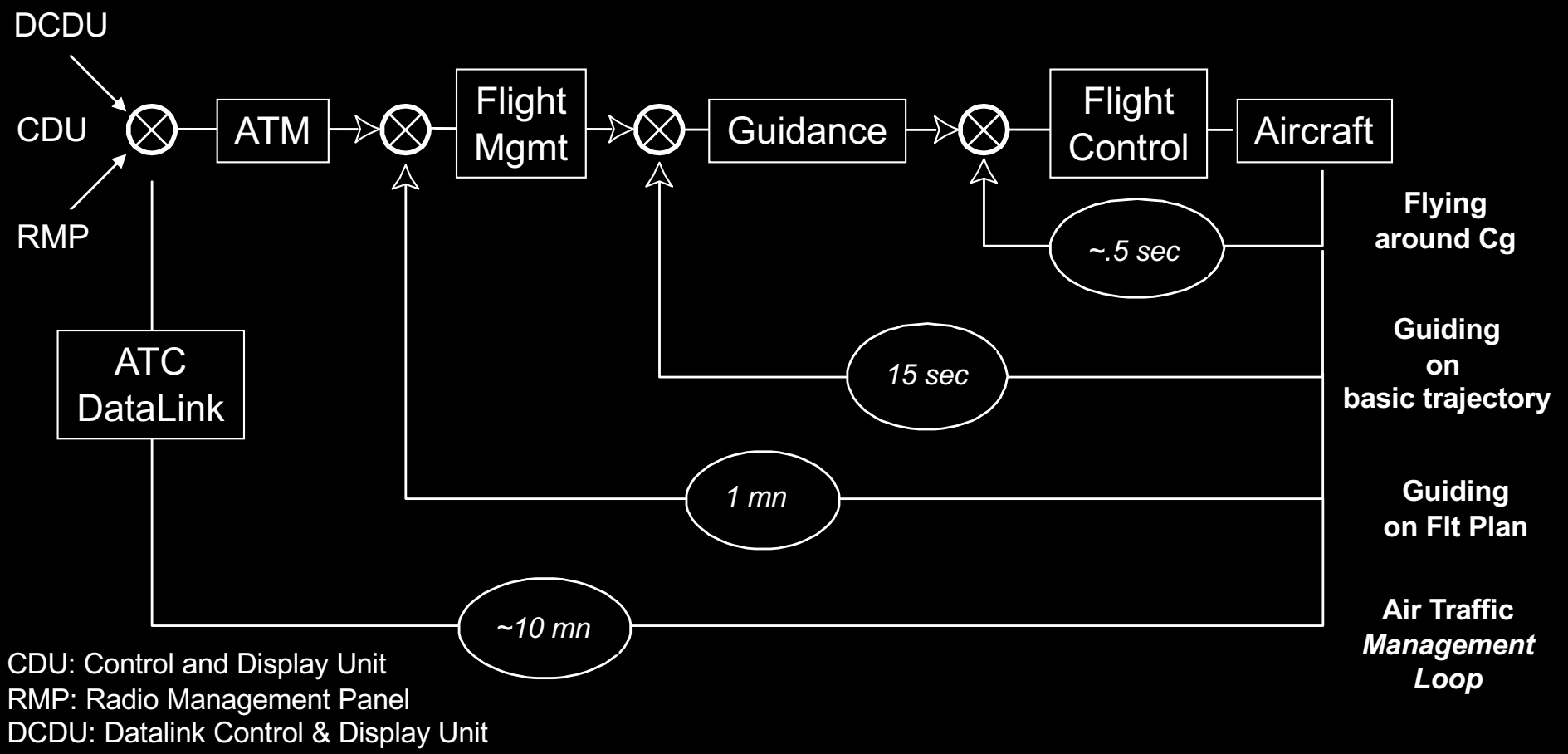
From Hardware to Software



Incremental Accumulation of Artificial Functions into Structure …

Automation

Loop 4: Automation of the ATM

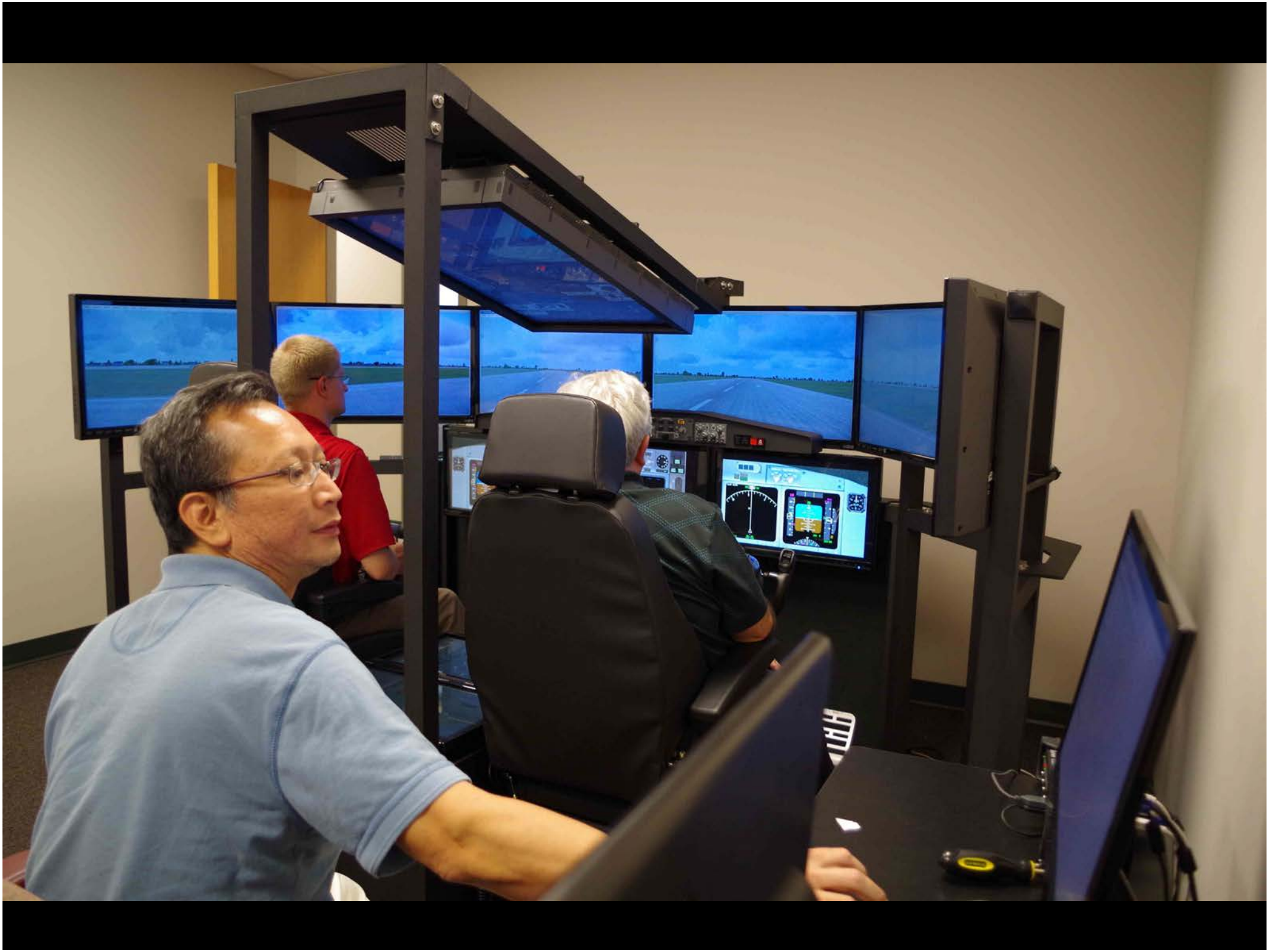


- Multi-agent integration
- From AT control to AT management (2nd revolution)


N339DF
N339DF

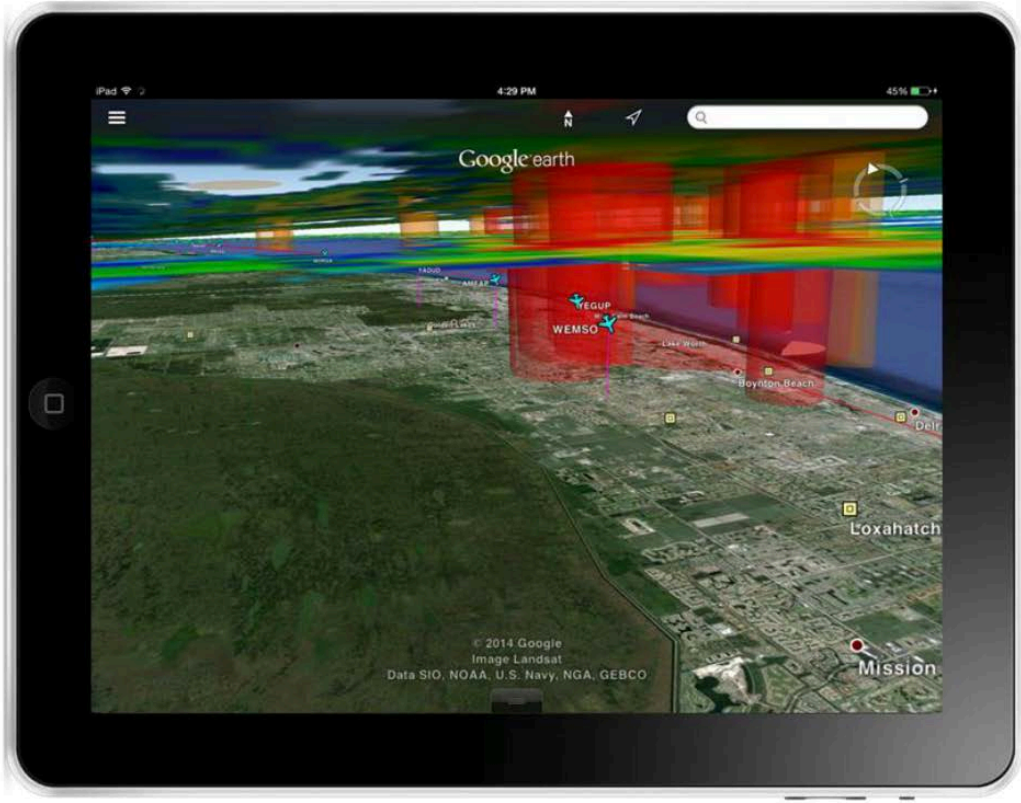
Organize Creativity Spaces…

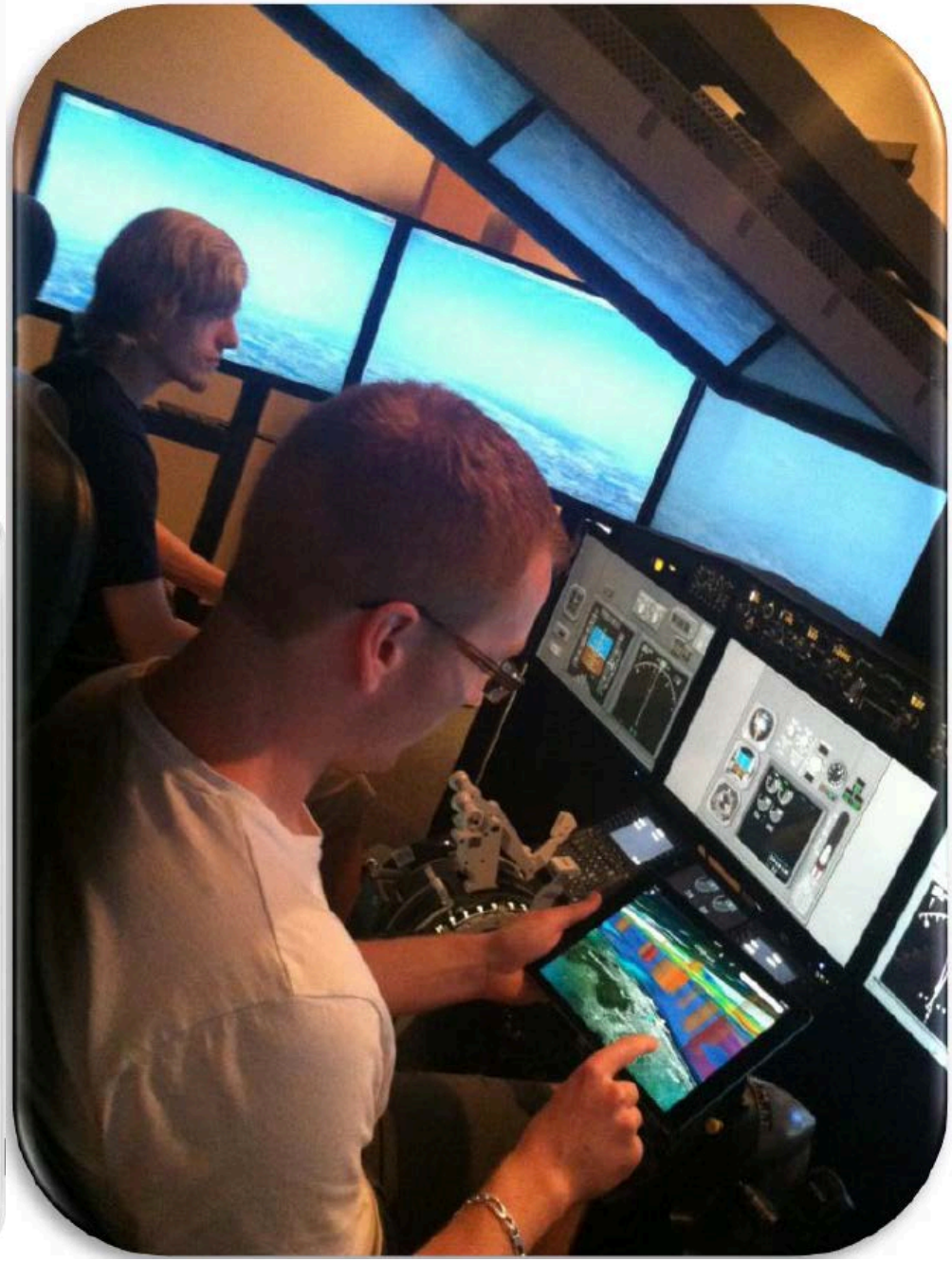

325
COCKPIT
RESEARCH



Tactical → Strategic

2D to 3D
Weather Visualization



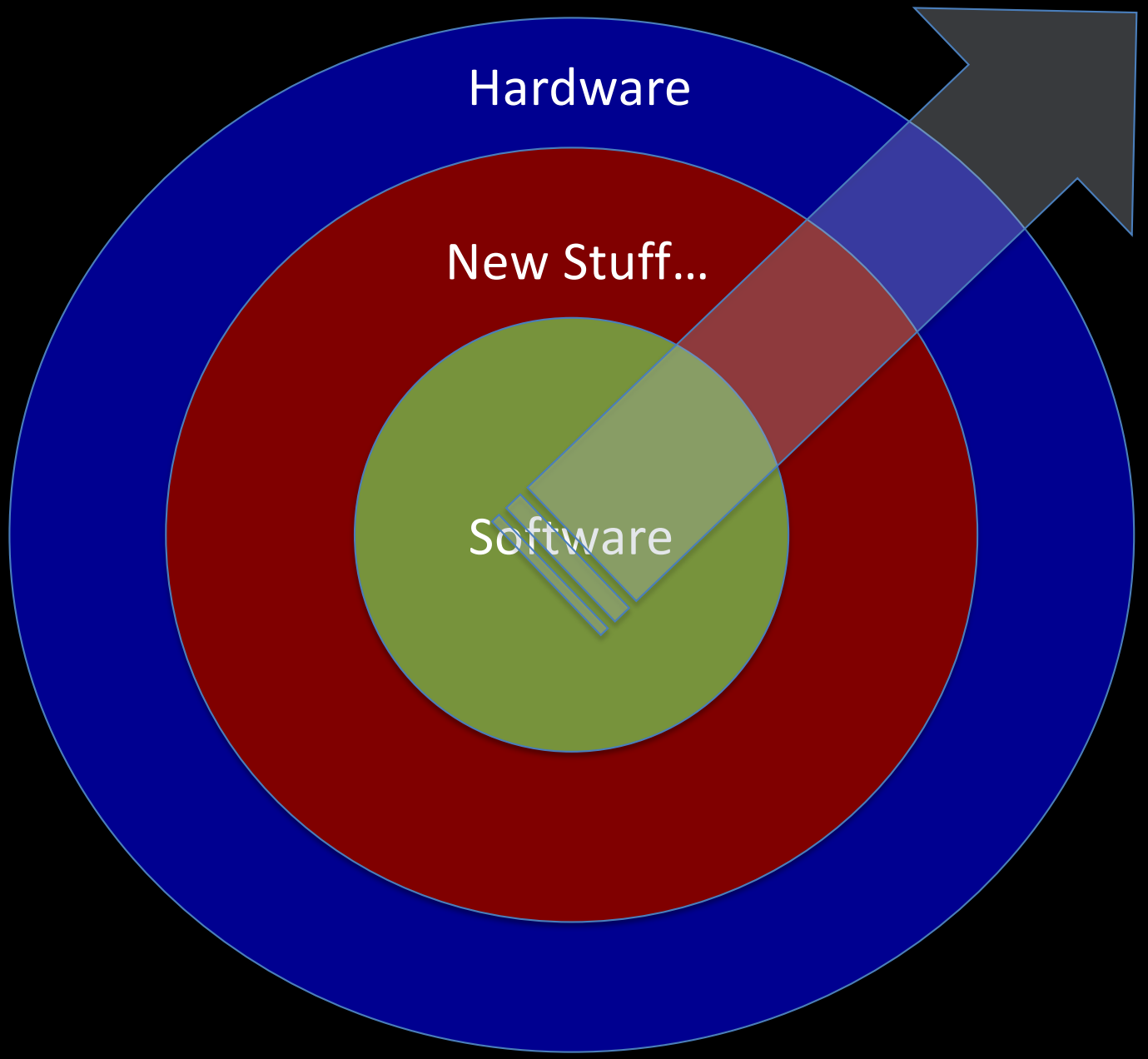


Onboard Weather Situation Awareness System

Onboard Context-Sensitive Information System

21st century

From Software to Hardware



Modeling
Simulation
Connectivity
Orchestration
3D Printing
…

Tangible Interactive Systems (TISs)

From Automation…
… to Tangible Interactive Systems (TISs)

From Automation…
… to Tangible Interactive Systems

Technology-Centered Engineering!

Human-Centered Design?

TISs…

Properties

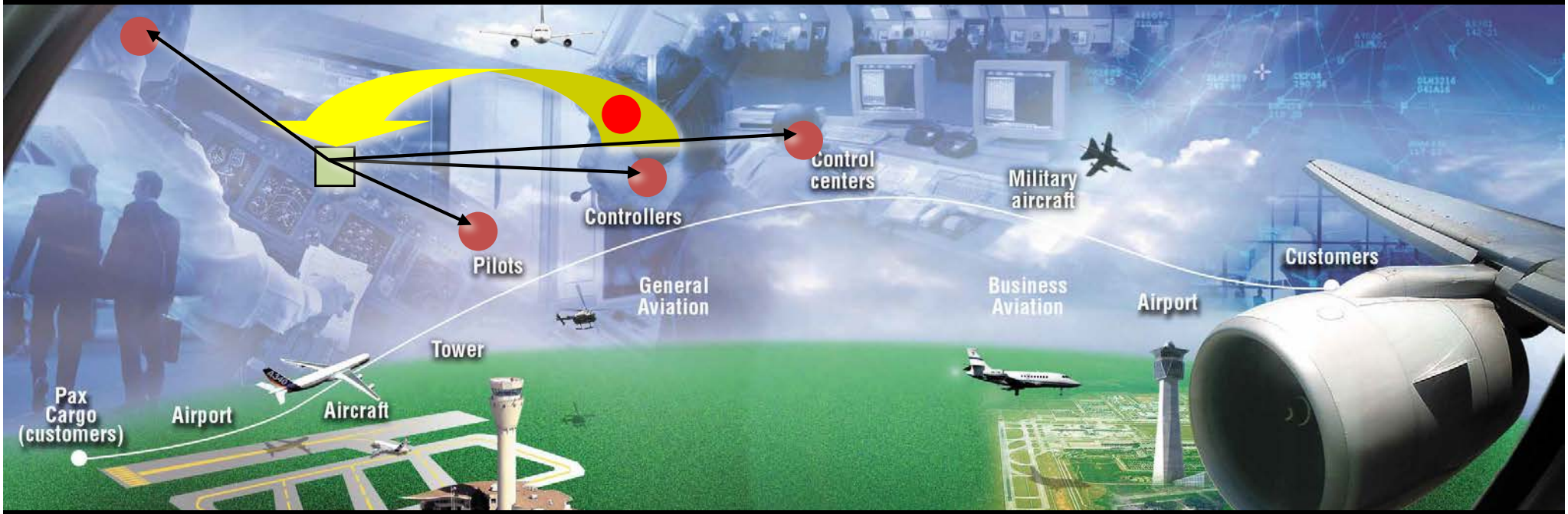
- Structural (hardware and organizational)
- Functional (software and organizational)

Cognitive Functions

Role
Context
Resources

TISs as Socio-Cognitive Organs

TISs in Air Traffic Management…



Machine cognitive function (TIO)

Human cognitive function

TISs in Air Traffic Management…

Flying in the early 21st century, in high density traffic, requires new competencies and TISs capable of handling **complexity** of the overall organization.

→ **Complexity Science**

Discover, model and use

Emergent Properties and Behaviors

TISs in Air Traffic Management…

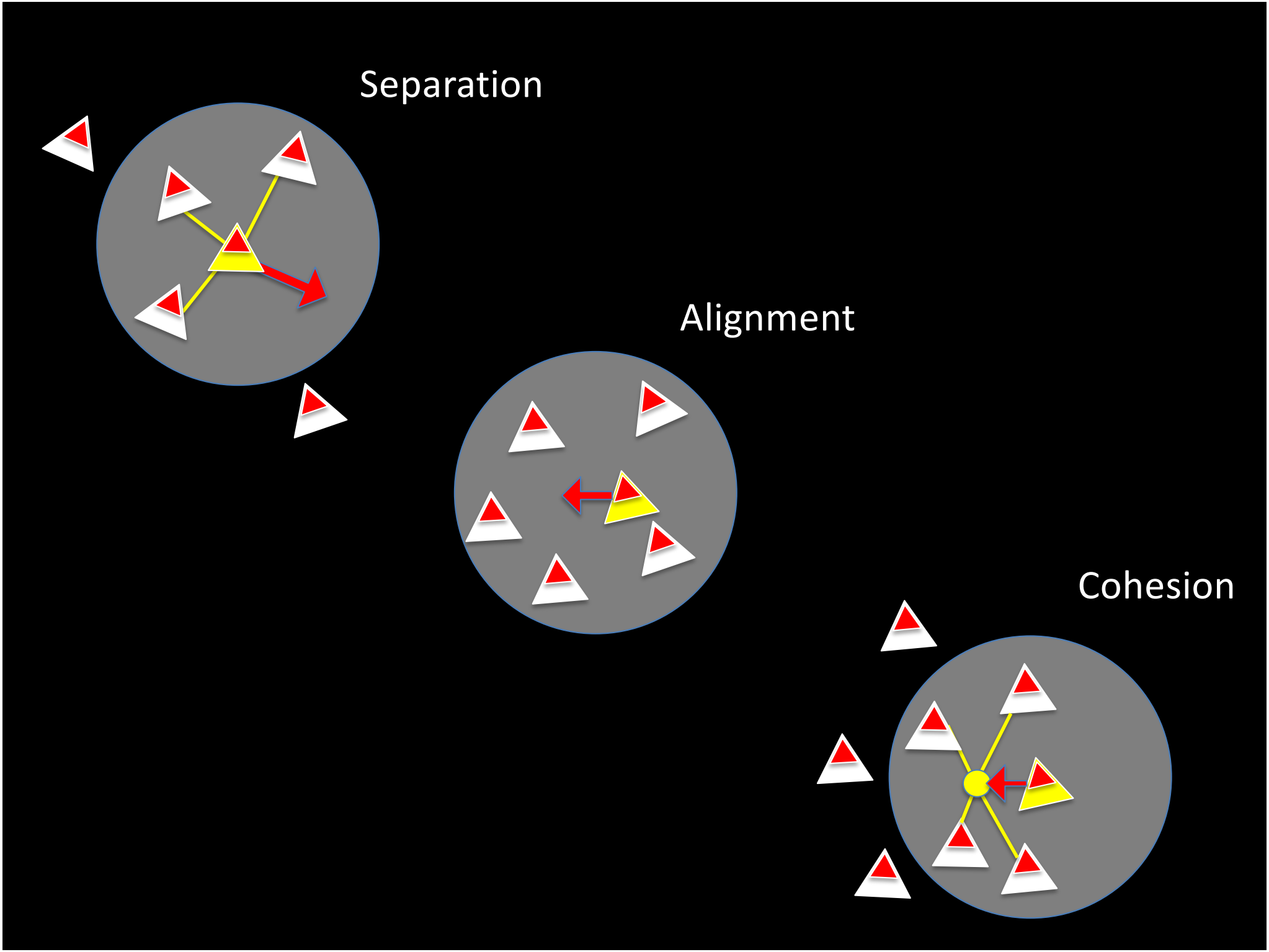
Air Show vs. Flock of birds

Automation

Manual & Automatic Control

Autonomy

Protection Envelopes ← **TISs**


Separation
Alignment
Cohesion

Two main types of TIS

Behaviors

Low Level TIS for low level control

autopilot

collision avoidance and automated recovery

…

Predictable

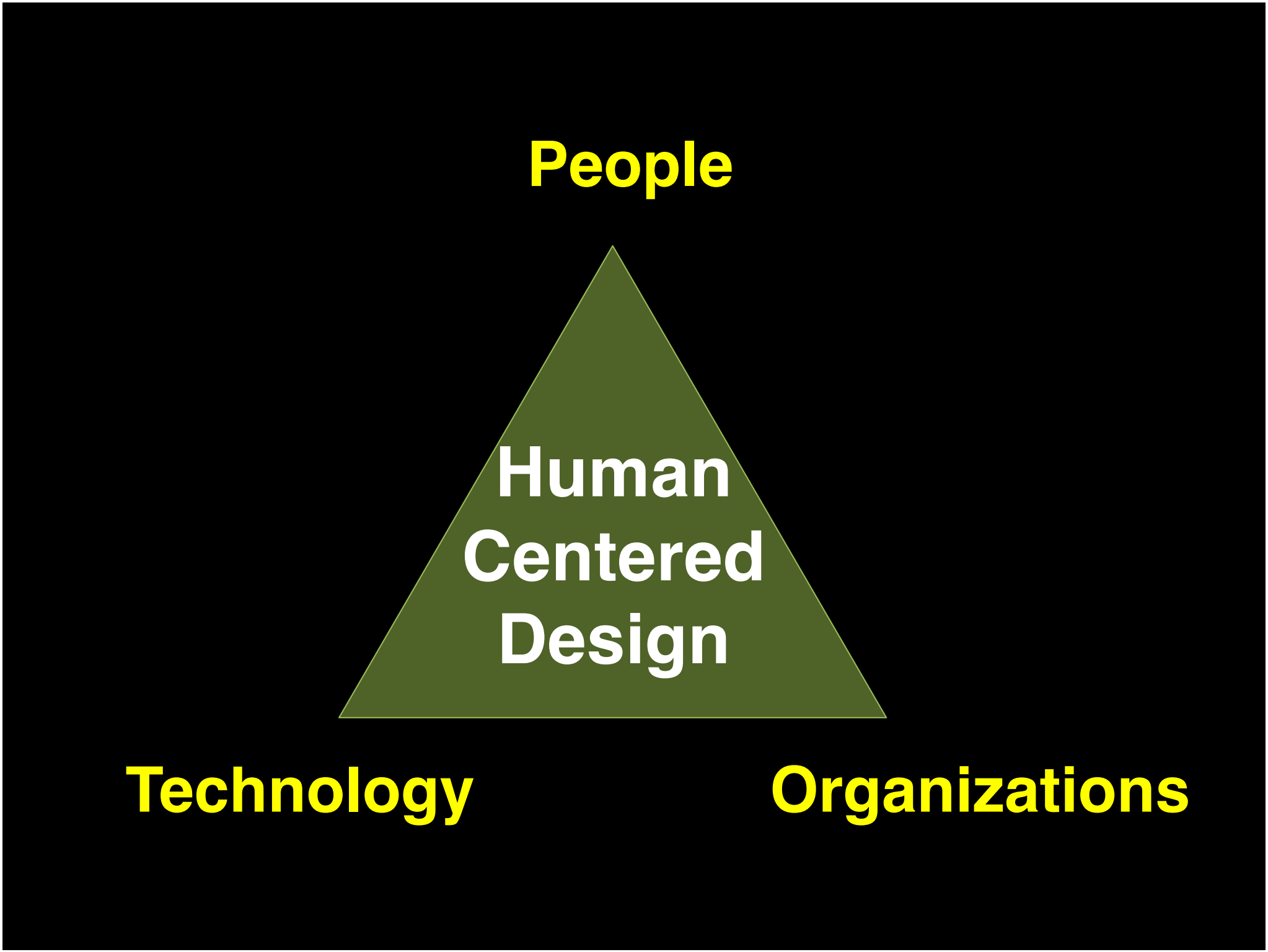
High Level TIS for high level management

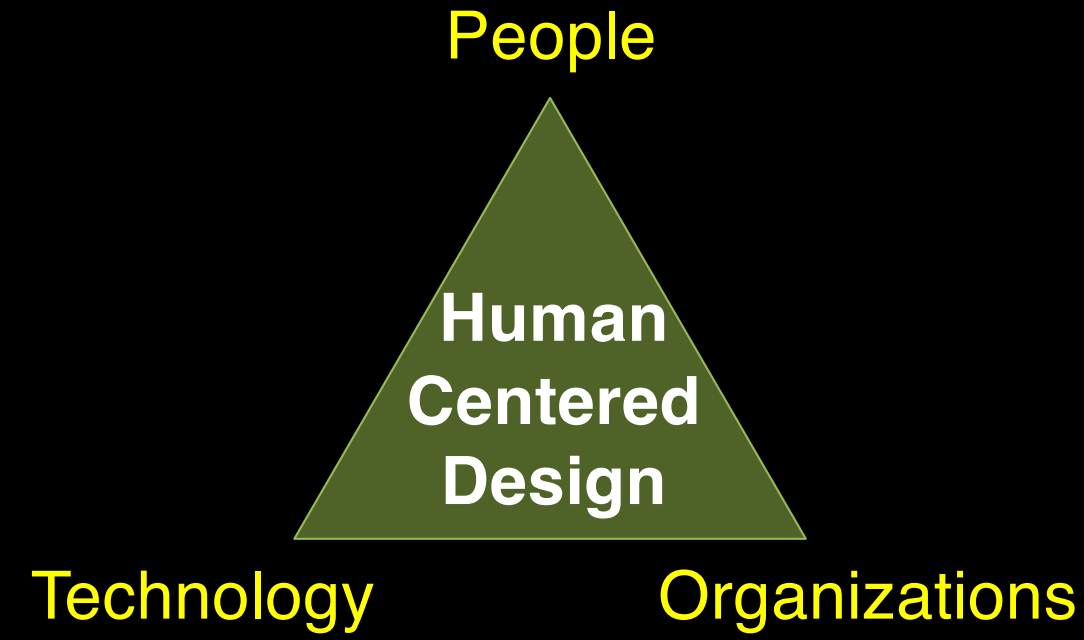
FMS

4D dynamic planning (traffic, weather, …)

…

Emergent


People
Human
Centered
Design
Technology
Organizations



Modeling and Simulation (Creativity)

Human-Systems Integration (Participatory Tests)

Complexity Management (Maturity)

Change management (Training)

This presentation was made thanks to

Sébastien Boulnois

Jarrett Clark

Gopal Jani

Thomas Laurain

Nicholas Kasdaglis

Lucas Stephane

Wei Tan

Thank You!…