Interaction Homme / Système complexe : Problématique et tendances

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Interactive Critical System Team

UNIVERSITÉ TOULOUSE III PAUL SABATIER Université de Toulouse

What is a complex system in our context

- Multiple “conflicting” properties – optimization as a compromise
- An underlying complex system
- A complex interactive system
  - Input/output hardware devices
  - Complex visualization, interaction and monitoring
- Complex operator tasks
- Complex operations (group of operators with different roles and responsibilities)
- Support of automations
  - Hard to understand
  - Hard to predict
  - Multiple drawbacks e.g. failures and de-skilling

Multiple “conflicting” properties

- **Usability** - ISO 9241 part 11 (efficiency, effectiveness, satisfaction)
- **User Experience** - ISO 9241 part 210 and [1] (aesthetics, emotions, identification, stimulation, meaning and value, social connectedness)
- **Dependability** - [2] (availability, integrity, safety, reliability, maintainability)
- **Reliability** - [2] (recoverability, wear-ability, continuity of correct service, continuity of performance of service)

[1] Pirker M., Bernhaupt R. **Measuring user experience in the living room: results from an ethnographically oriented field study indicating major evaluation factors**. EuroITV 2011, ACM DL, 79-82

[2] Avizienis, A., Laprie, J.-C., Randell, B., Landwehr, C. **Basic concepts and taxonomy of dependable and secure computing**. IEEE Trans. on Dependable and Secure Computing, vol.1, no.1, pp. 11- 33, 2004

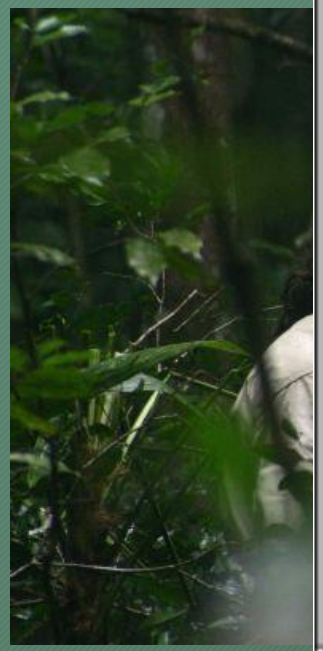
Two different views on Human-Computer Interaction

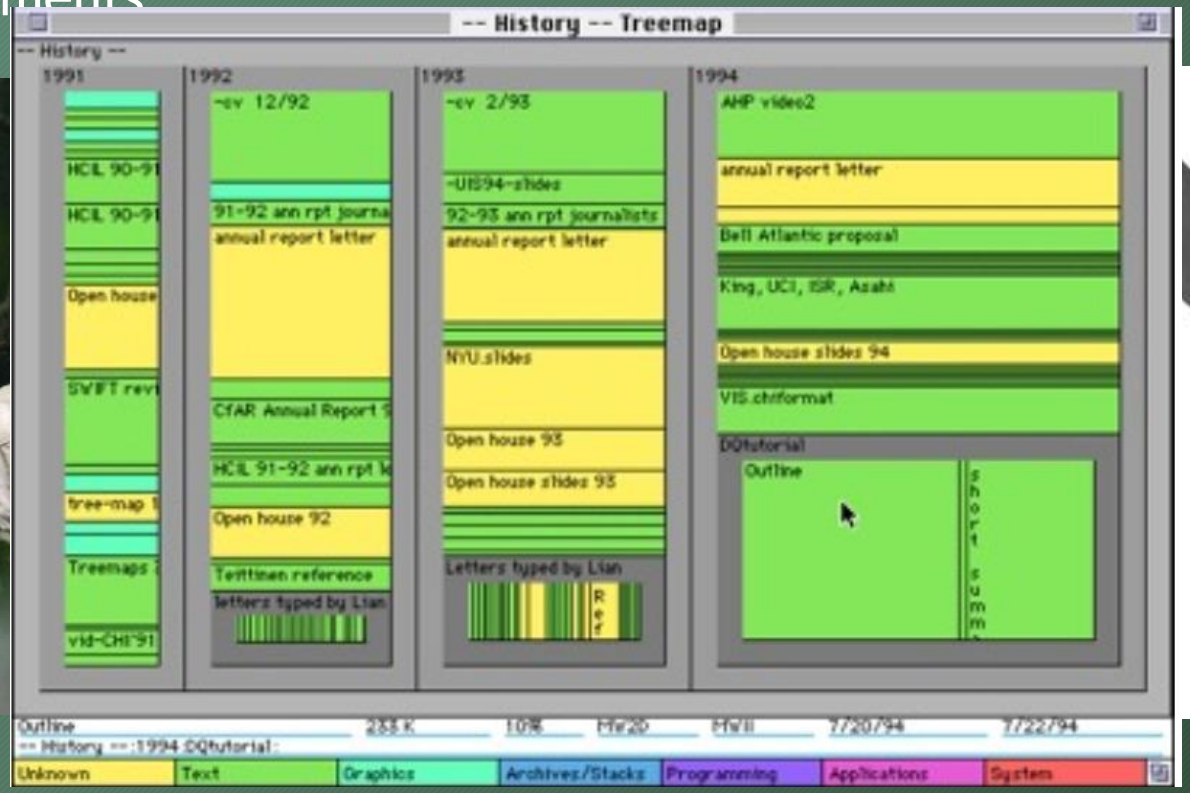
- Design, innovation, exploration
  - Exploratory work (finding a way in the jungle of possibilities)
  - Evaluate the way with a small group of people in controlled experiments

Two different views on Human-Computer Interaction

B. Shneiderman, “The eyes have it: a task by data type taxonomy for information visualizations,” Proceedings 1996 IEEE Symposium on Visual Languages, Boulder, CO, USA, 1996, pp. 336-343, doi: 10.1109/VL.1996.545307.

experiments





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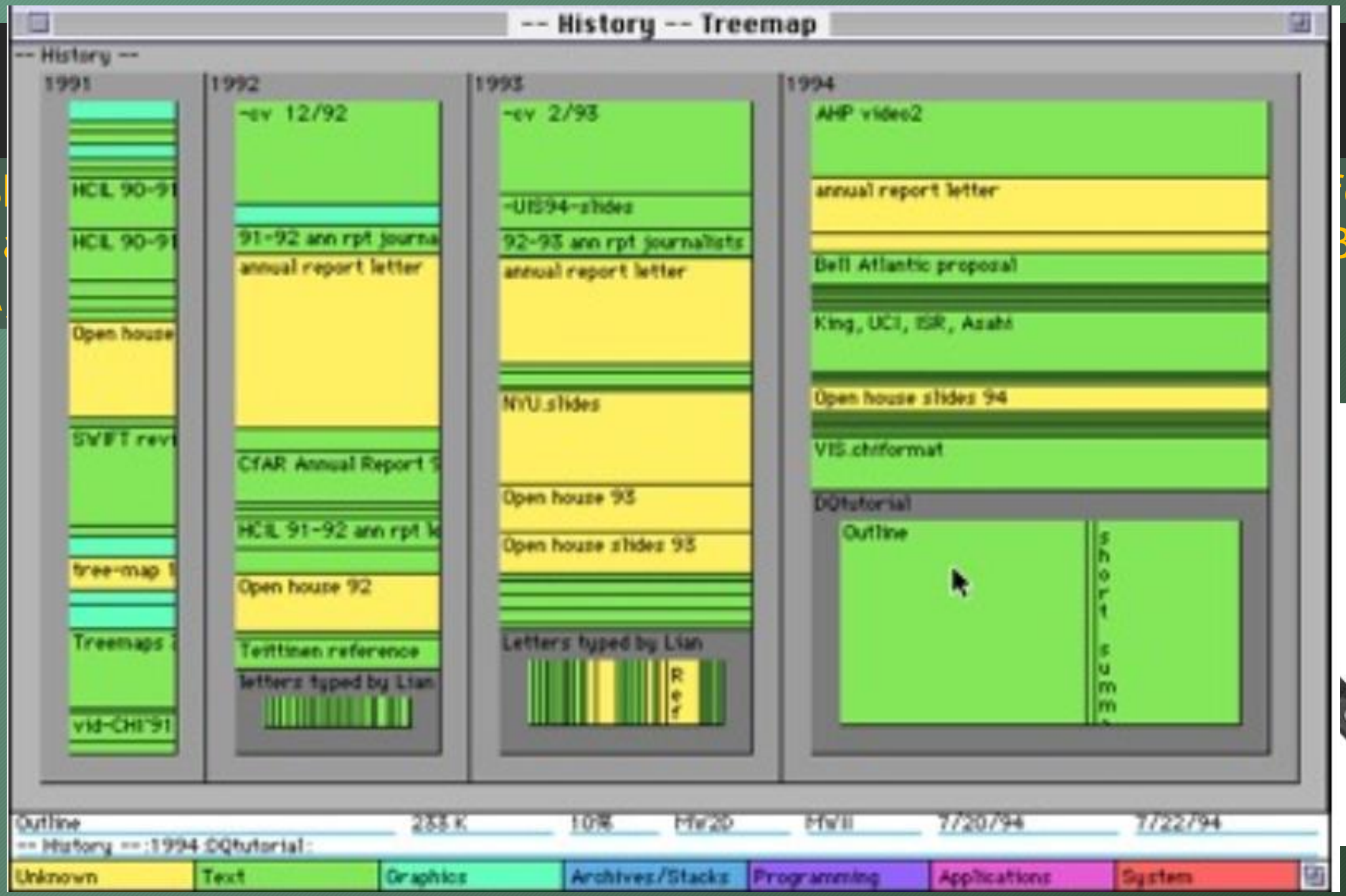


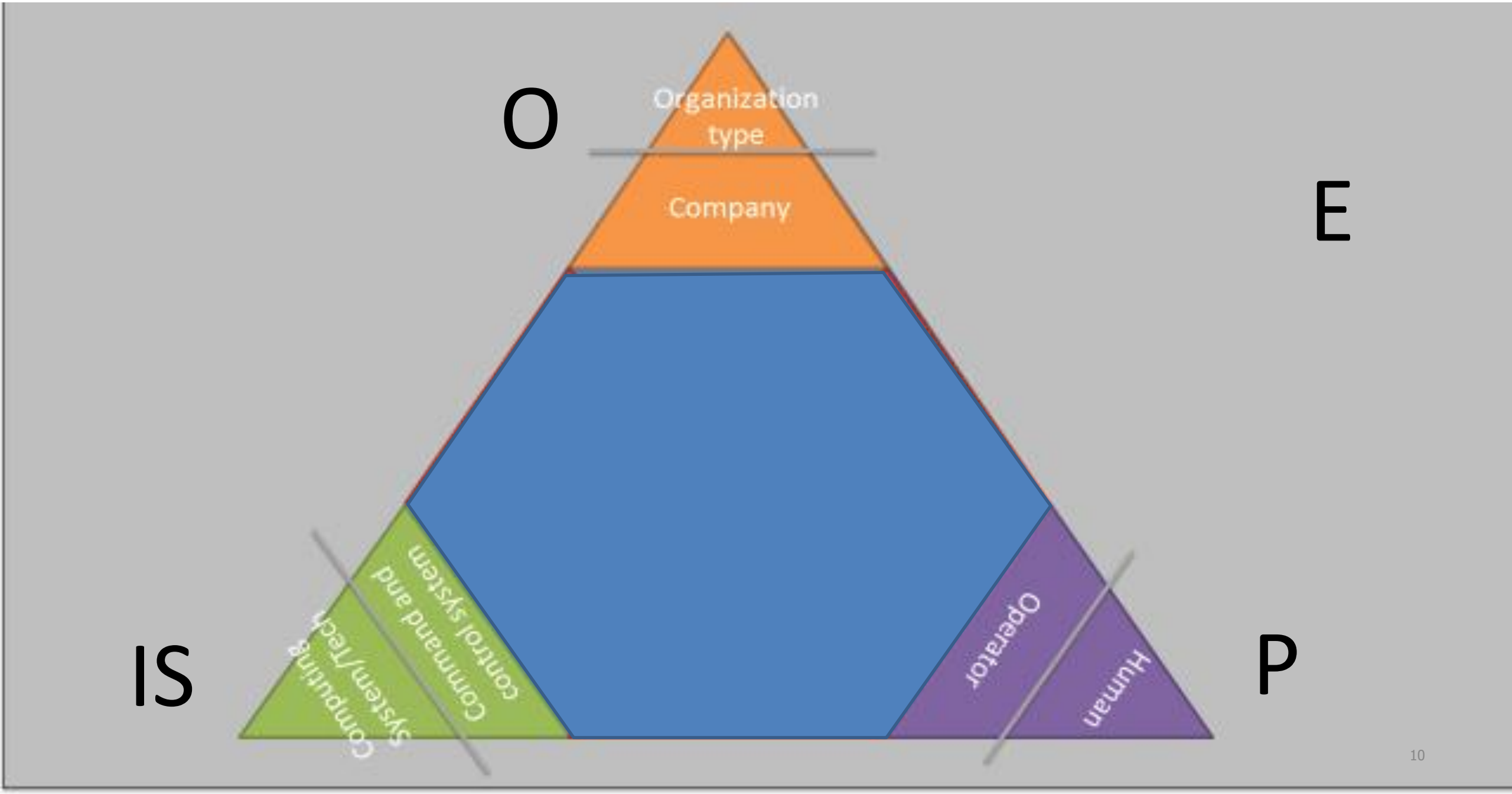
Two different views on Human-Computer Interaction

- Design, innovation, exploration
- Specification, engineering, inclusion into products
  - Definition of notations, tools, methods and processes to engineer multimodal interactive systems (interactions and interfaces)
  - Conformance to (and definition of) standards, deployment and maintenance

Outline

- The need for a systemic framework
- The need for a systematic approach
- The need to cope with complexity (the system, the human, the organization and the environment)
  - Understanding (deep knowledge about people, organizations, systems and interactive technologies)
  - Modeling
  - Analyzing
  - Designing
  - Developing
  - Deploying
  - Maintaining
  - Decommissioning
- Systemic approach and a concrete example from Aviation
- The issue of training and a concrete example from CSG

The need for a systemic view to describe People, Organizations, Interactive Systems and Environment


O
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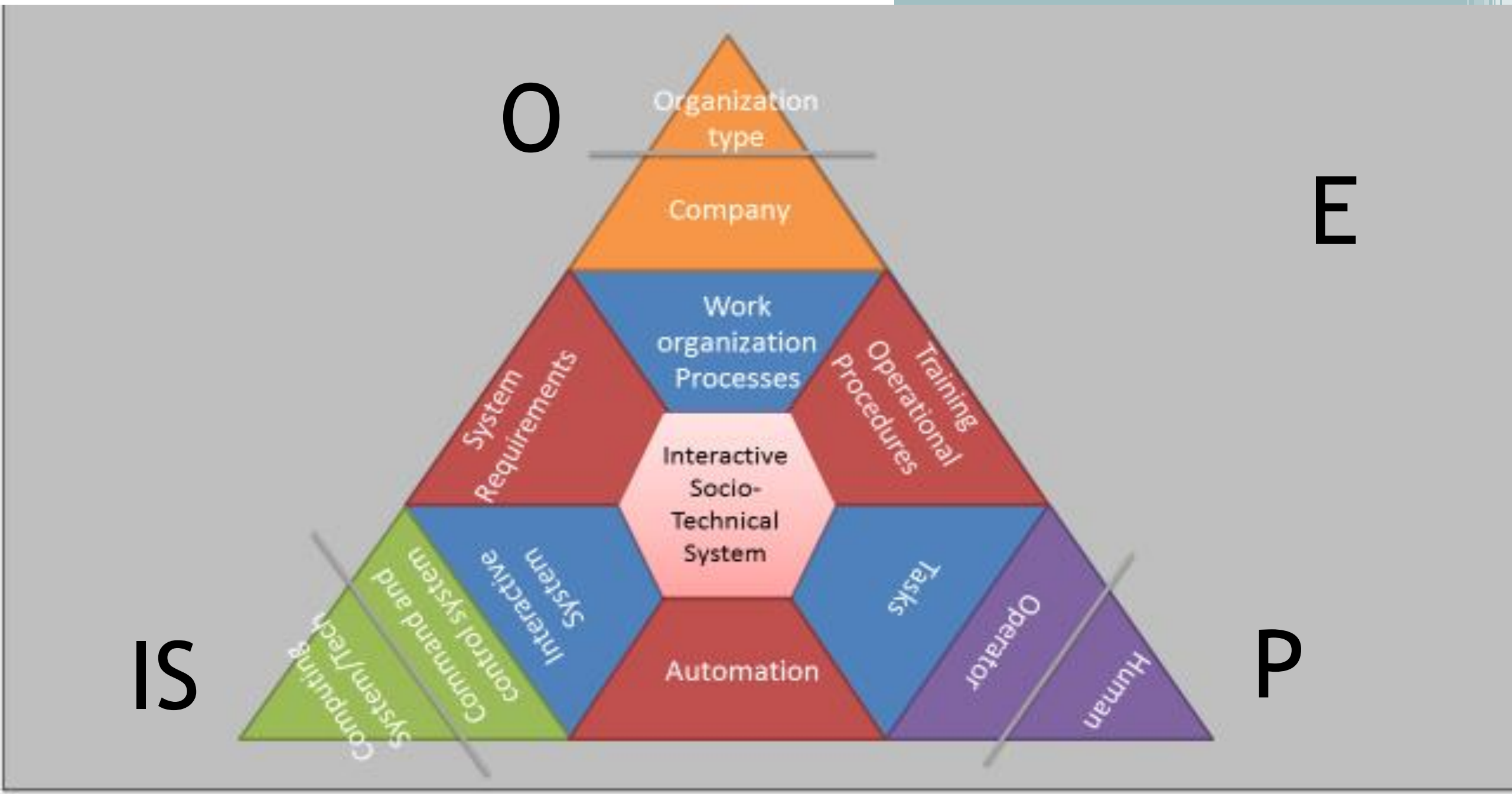
E
IS
Computing System/Tech
Command and control system
Operator
Human
P


O
E
IS
P
Organization type
Company
Work organization Processes
System Requirements
Training Operational Procedures
Interactive Socio-Technical System
Interactive system
Computing system/Tech
Command and control system
Automation
Tasks
Operator
Human

P-O-IS-E – POISE

poise

noun [U] • **UK** /pɔɪz/ **US** /pɔɪz/ APPROVING

calm confidence in a person's way of behaving, or a quality of grace (= moving in an attractive way) and balance in the way a person holds or moves their body:

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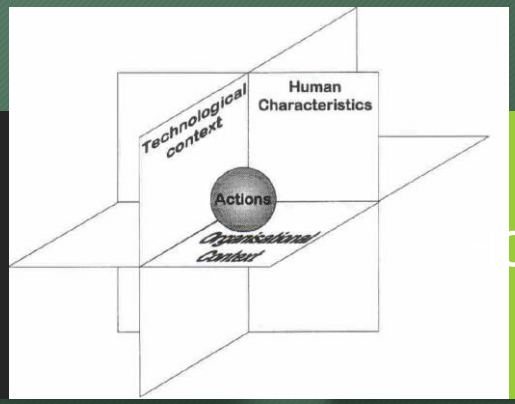

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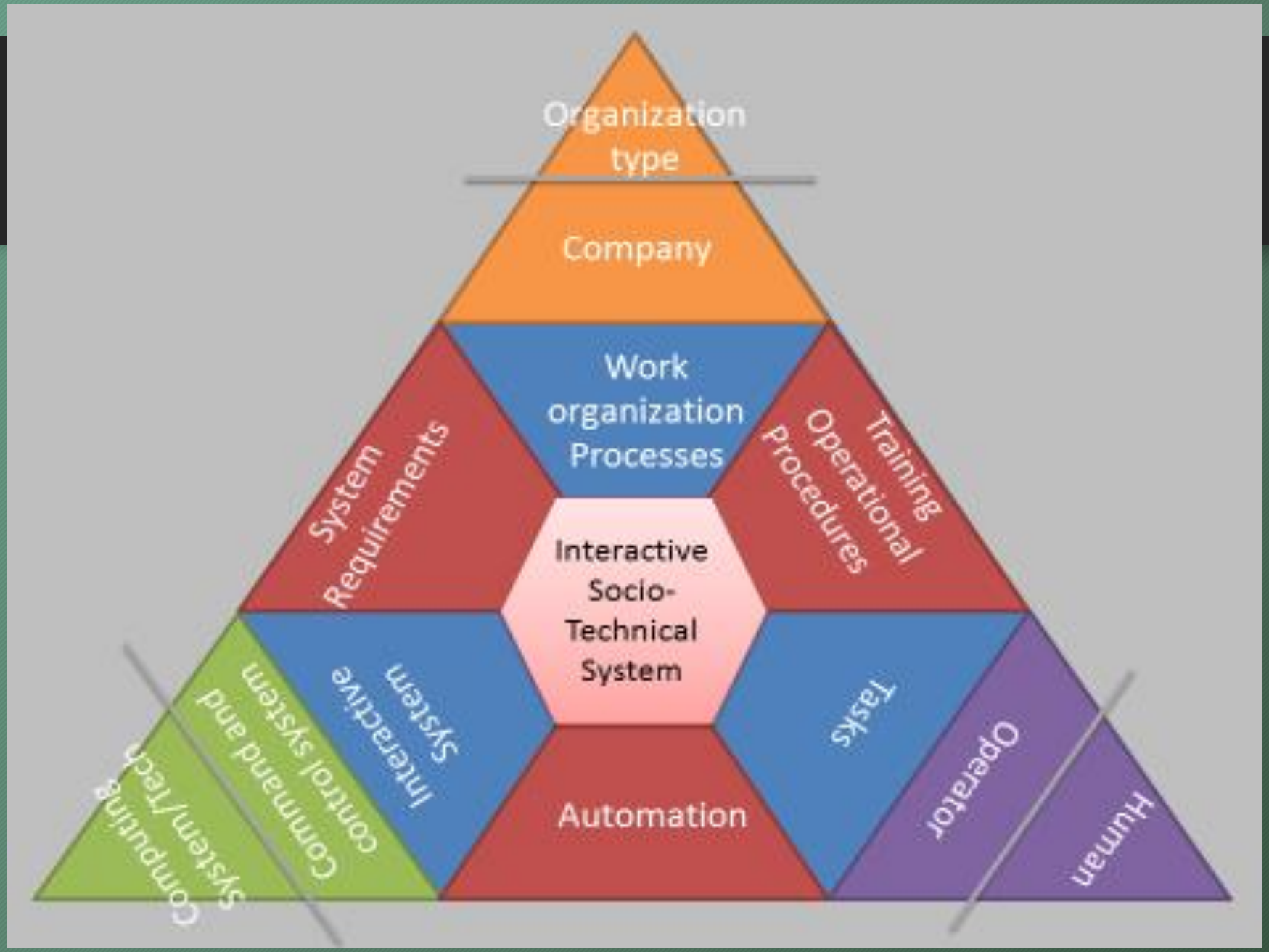

E. Hollnagel. 1997. **Cognitive ergonomics: it's all in the mind.** Ergonomics 40, 10 (1997), 1170-1182

Ragosta et al. 2015. **Concept Maps for Integrating Modeling Techniques for the Analysis and Re-Design of Partly-Autonomous Interactive Systems.** 5th Int. Conf. (ATACCS '15), ACM, 41-52

P. Palanque. **POISE: A Framework for Designing Perfect Interactive Systems with and for Imperfect People.** INTERACT (1) 2021: 39-59

ARINC

COCKPIT DISPLAY SYSTEM INTERFACES TO USER SYSTEMS

ARINC SPECIFICATION 661-6

PUBLISHED: September 1, 2016

Prepared by the AEEC
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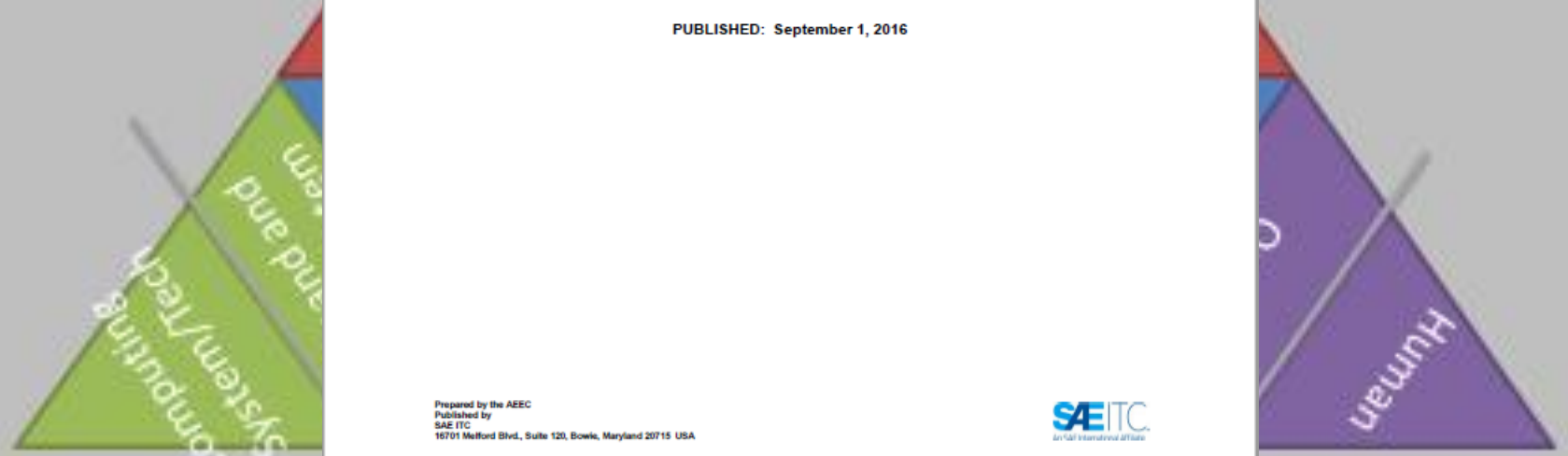

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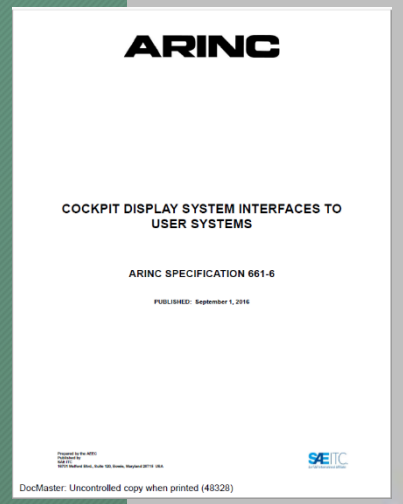

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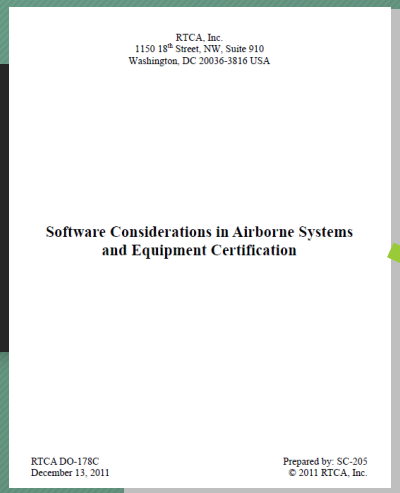
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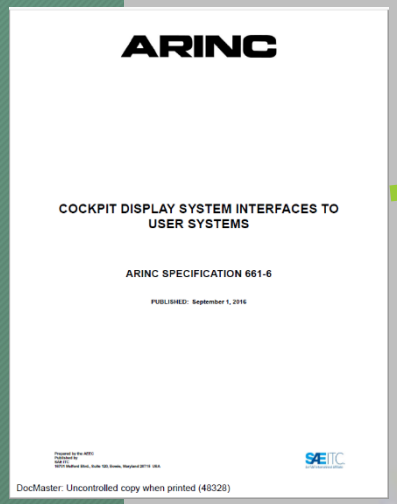
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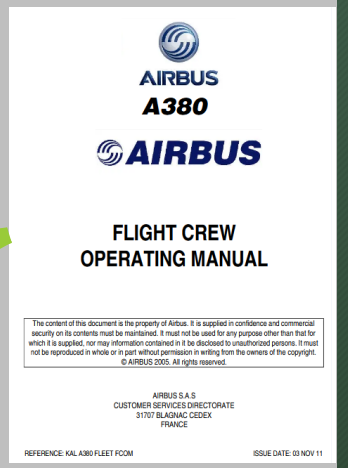
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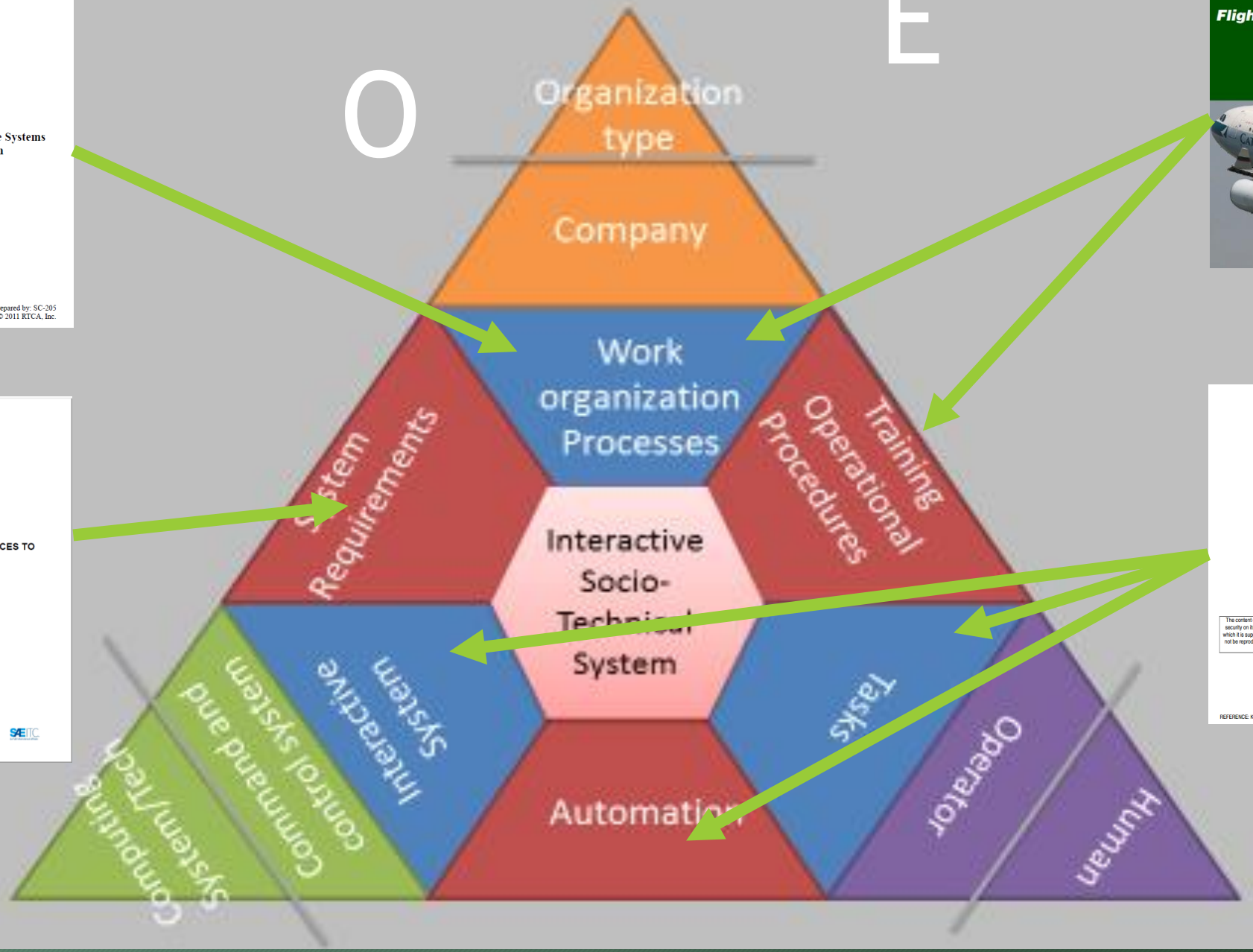

P-O-IS-E – POISE (People, Organization, Interactive System and Environment)

poise

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NO NEED TO HURRY!!!

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IT'S DANGEROUS TO HURRY!!!

A concrete example from Aviation


ESC
DIR
PERF
INIT
NAV AID
MAIL BOX
F-PLN
DEST
SEC INDEX
SURV
ATC COM
ND
Q W E R T Y U I O P CLR
A S D F G H J K L
/ Z X C V B N M SP ENT
ESC
KBD
1 2 3
4 5 6
7 8 9
• 0 +/-
CCD
KBD
ON
OFF
ON
OFF


ESC
DIR
PERF
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NAV AID
MAIL BOX
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DEST
SEC INDEX
SURV
ATC COM
ND
CLR
ENT
SP
ESC
KBD
CCD
KBD
ON
OFF
ON
OFF

ARINC 661 Standard interactive objects


FMS
AI1001
ACTIVE
POSITIO
SEC
DATA
CONFIG
ACTIVE / FPLN
xxx xxx
FROM UTC
EFOB-T.WIND
TRK DIST FPA
KIAD
SWANN
V268
GOLDA
V268
BROSS
J42
OOD
(T/C)
J42
DAVYS
J42
BRAND
J42
RVB
BRG
089° 58
093° 8
094° 7
057° 37
060° 2
060° 22
061° 10
061° 14
INSERT WPT
DELETE *
DEPARTURE
ARRIVAL
OFFSET
HOLD
AIRWAYS
OVERFLY *
ENABLE ALTN *
NEW DEST
CONSTRAINTS
CMS
WIND
STEP ALTS
DEST
LFPG
07:42
FPLN-INFO
DIR TO
LINE 1 - 35 CHAR
LINE 2 - 35 CHAR
MSG LIST


First Officer
Captain
FMS
AI1001
ACTIVE
POSITIO
SEC
DATA
CONFIG
ACTIVE / FPLN
FROM
UTC
TRK
DIST
FPA
KIAD
SWANN
GOLDA
V268
BROSS
J42
OOD
(T/C)
DAVYS
BRAND
RVB
INSERT WPT
DELETE *
ARRIVAL
OFFSET
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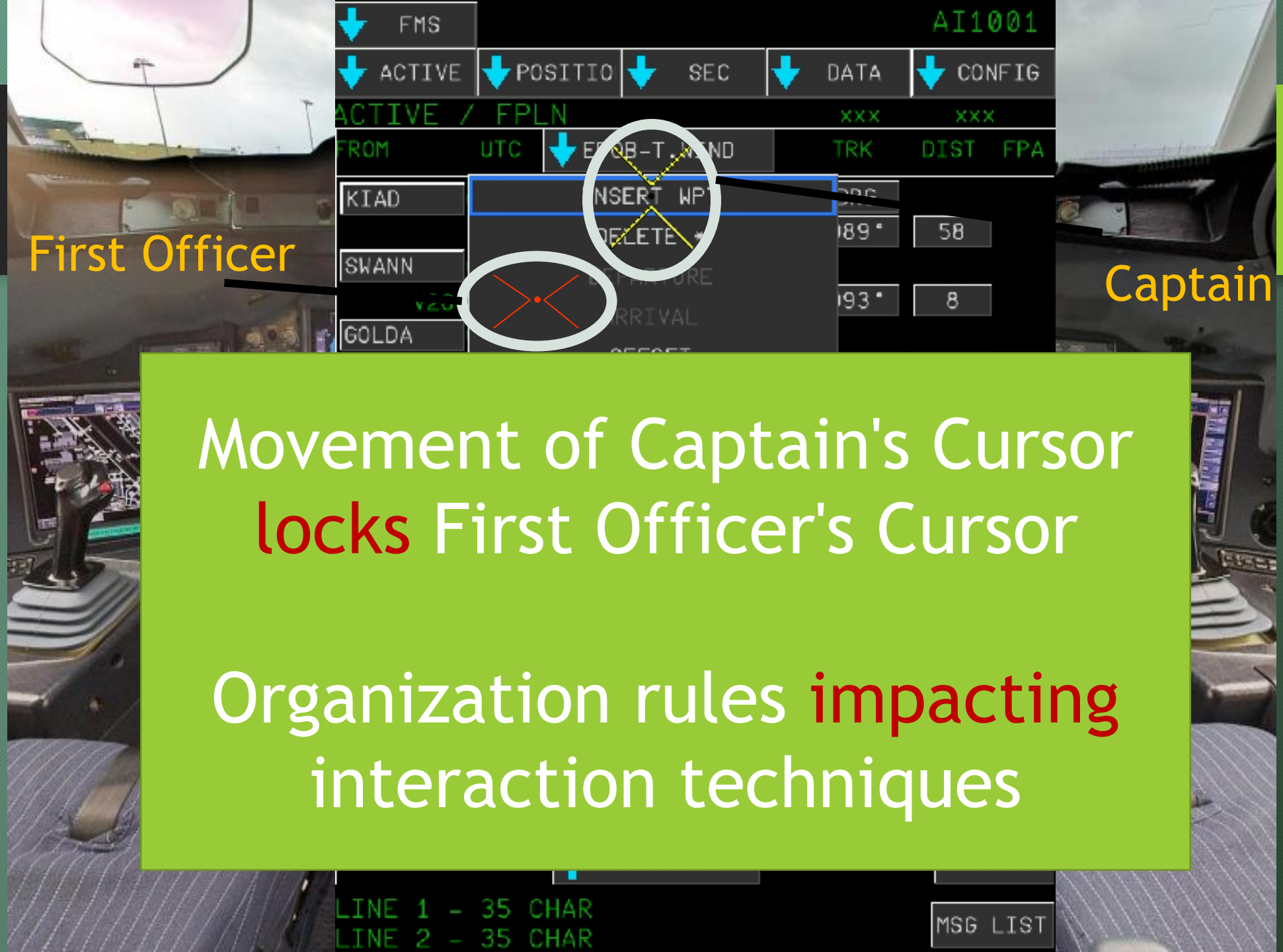
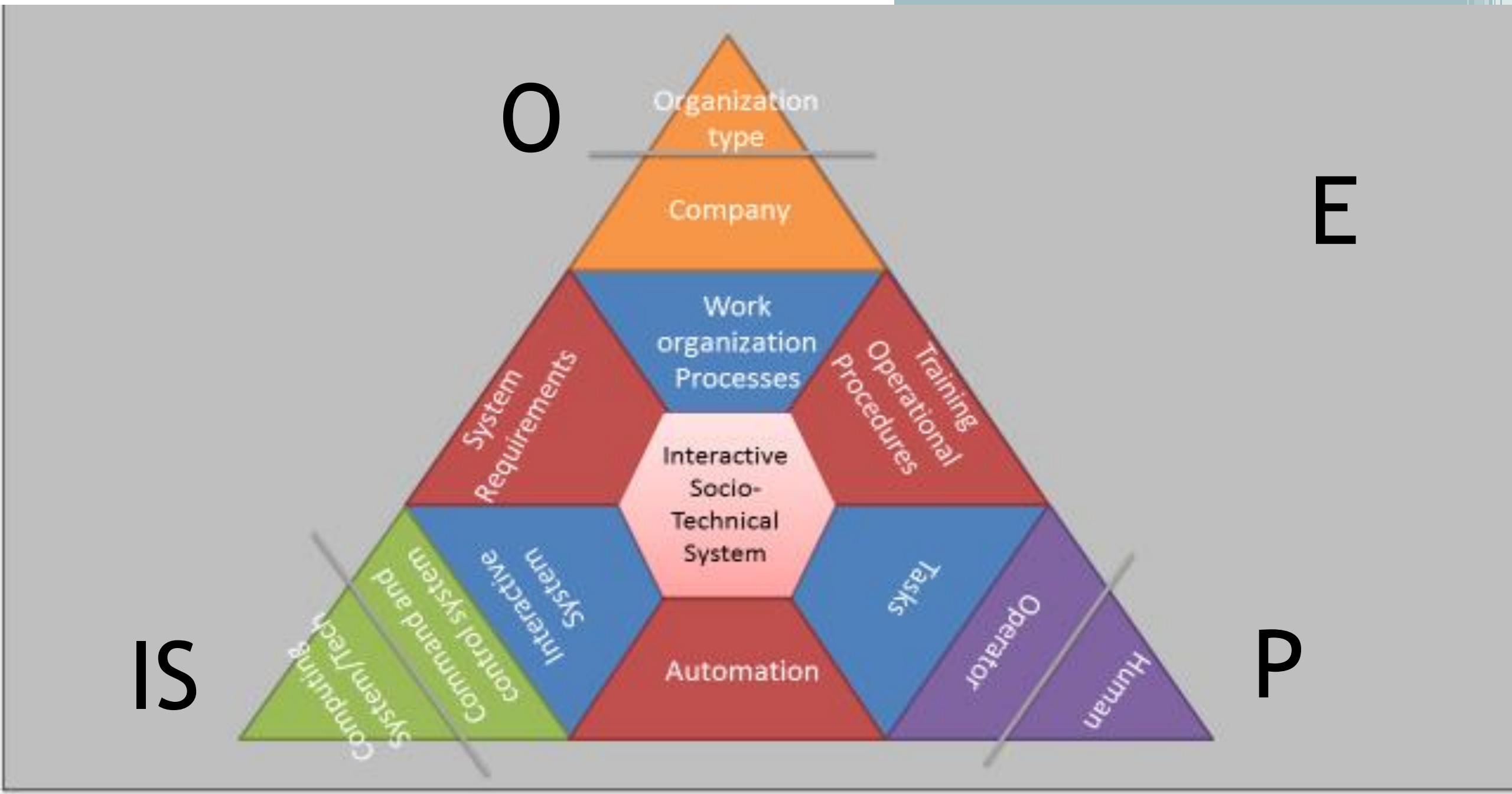


Movement of Captain's Cursor **locks** First Officer's Cursor

Organization rules **impacting** interaction techniques


O
Organization type
Company
E
Work organization Processes
System Requirements
Training Operational Procedures
Interactive Socio-Technical System
Interactive system
Computing system/Tech
Command and control system
Automation
Tasks
Operator
Human
IS
P

Outline

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  - Decommissioning
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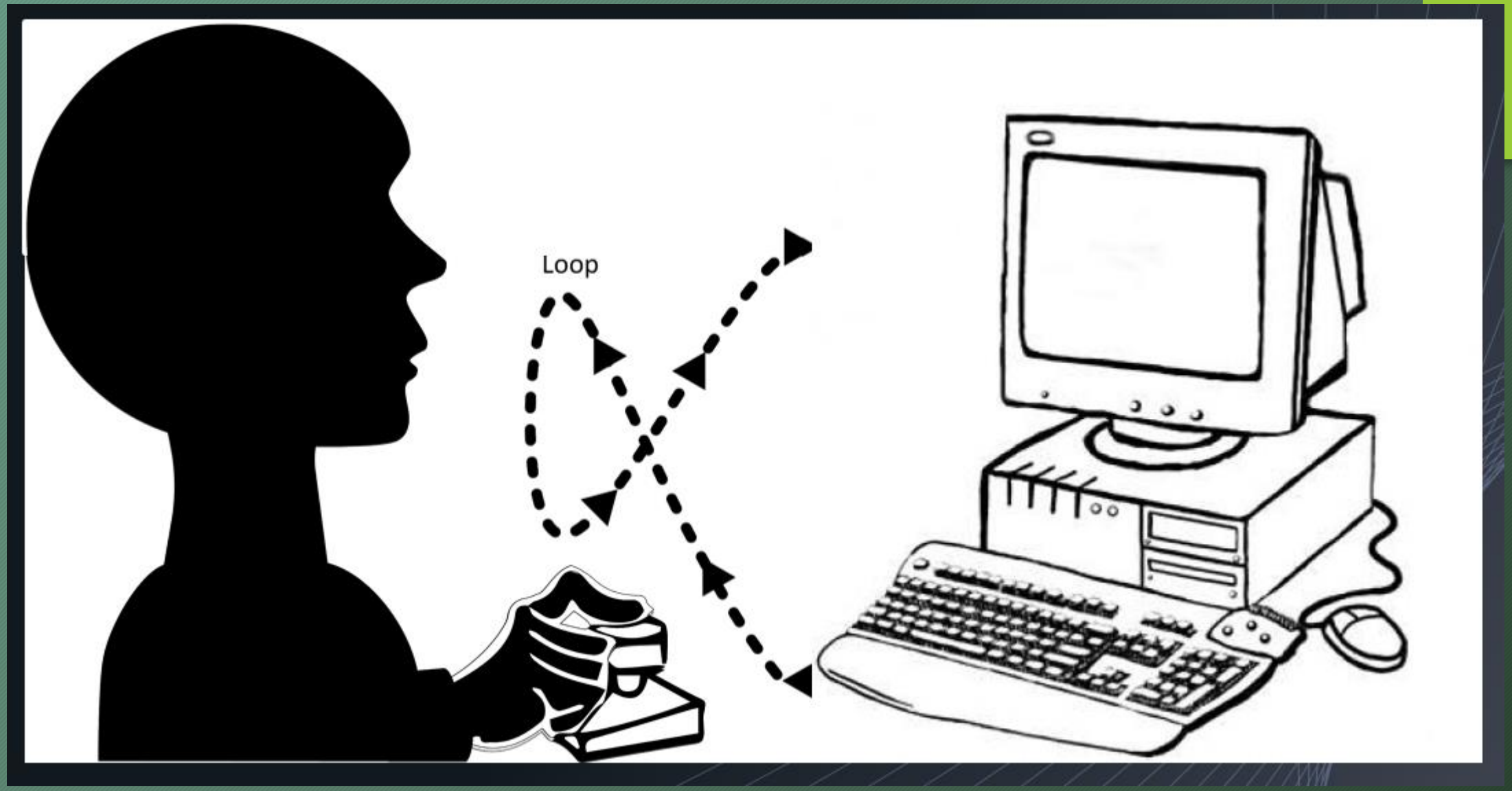
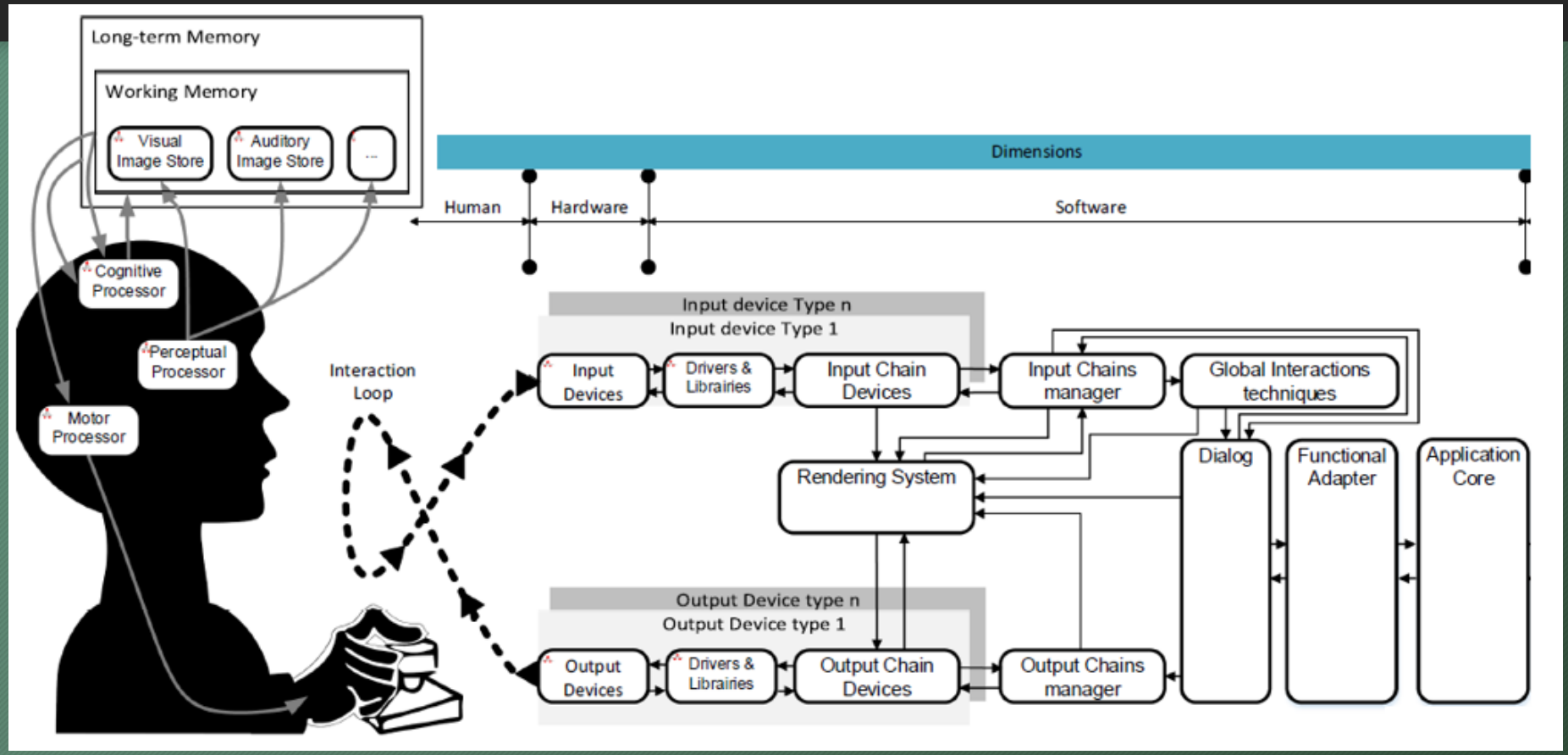
- The issue of training and a concrete example from CSG

Systematic approach to describe interactive systems (hardware and software integration)

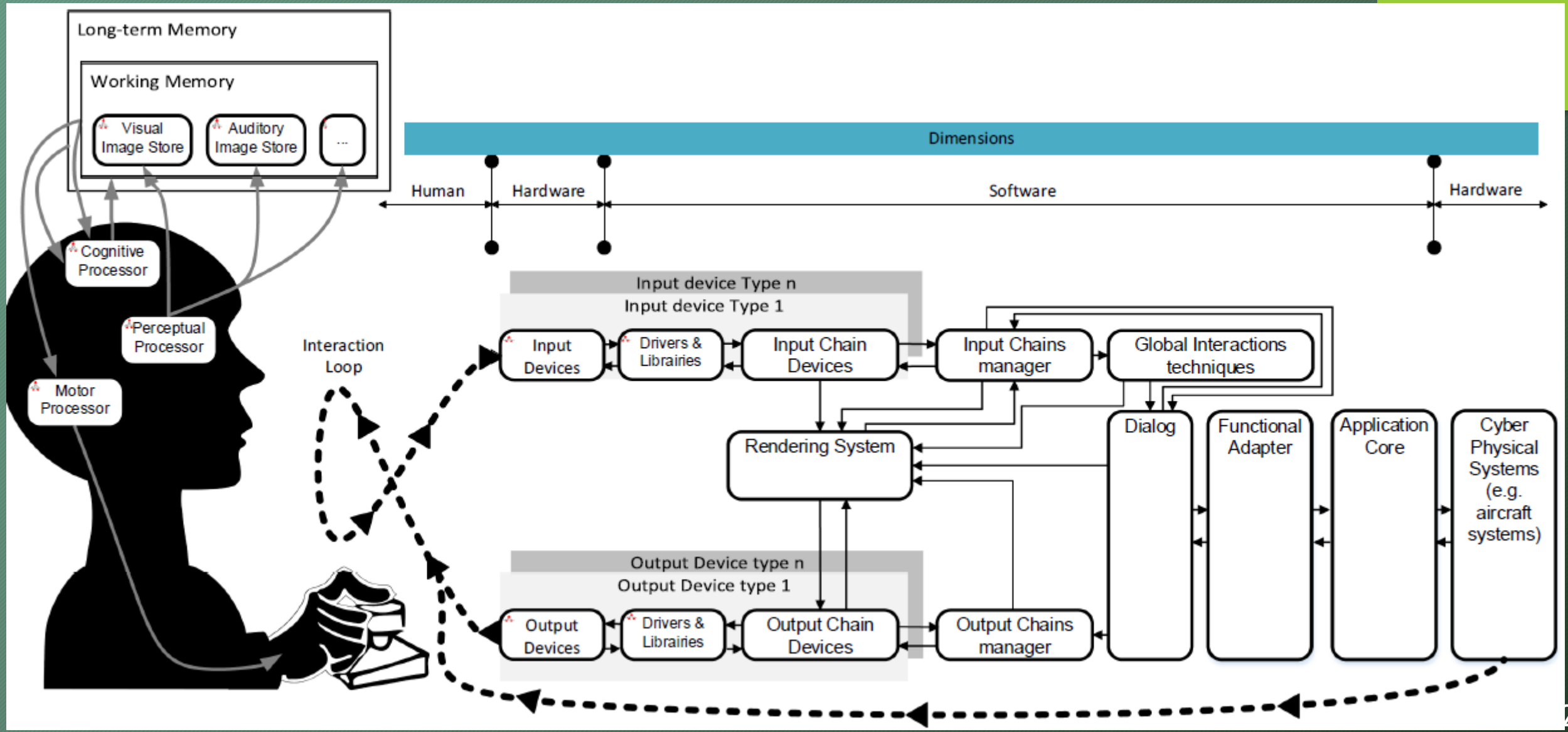
The HCI Loop



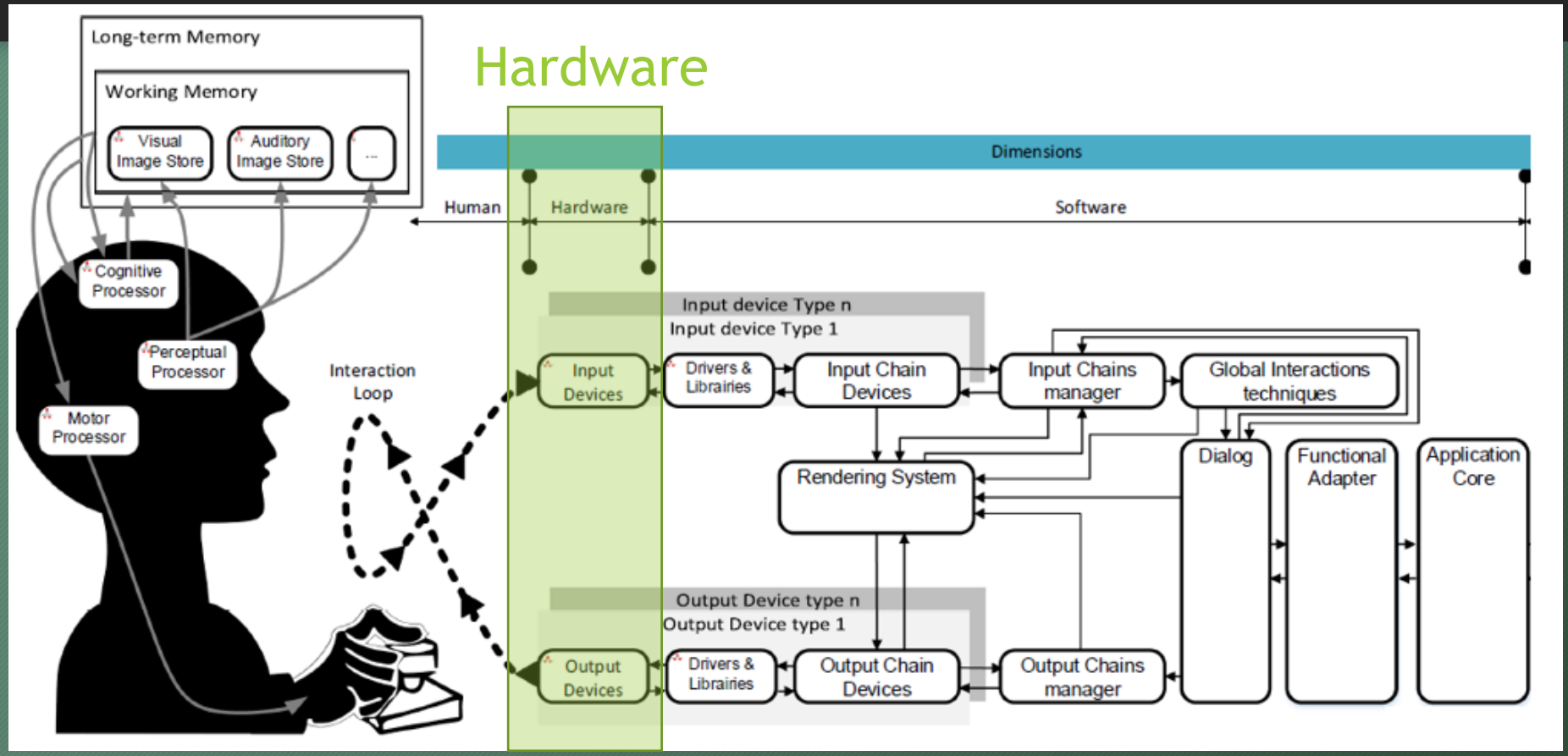
The HCI Loop


Long-term Memory
Working Memory
Visual Image Store
Auditory Image Store
...
Cognitive Processor
Perceptual Processor
Motor Processor
Interaction Loop
Dimensions
Human
Hardware
Software
Input device Type n
Input device Type 1
Input Devices
Drivers & Librairies
Input Chain Devices
Input Chains manager
Global Interactions techniques
Rendering System
Dialog
Functional Adapter
Application Core
Output Device type n
Output Device type 1
Output Devices
Drivers & Librairies
Output Chain Devices
Output Chains manager

Martin Cronel, Bruno Dumas, Philippe A. Palanque, Alexandre Canny, **MIODMIT: A Generic Architecture for Dynamic Multimodal Interactive Systems**. IFIP WG 13.2 conference HCSE 2018, LNCS, 109-129



The HCI Loop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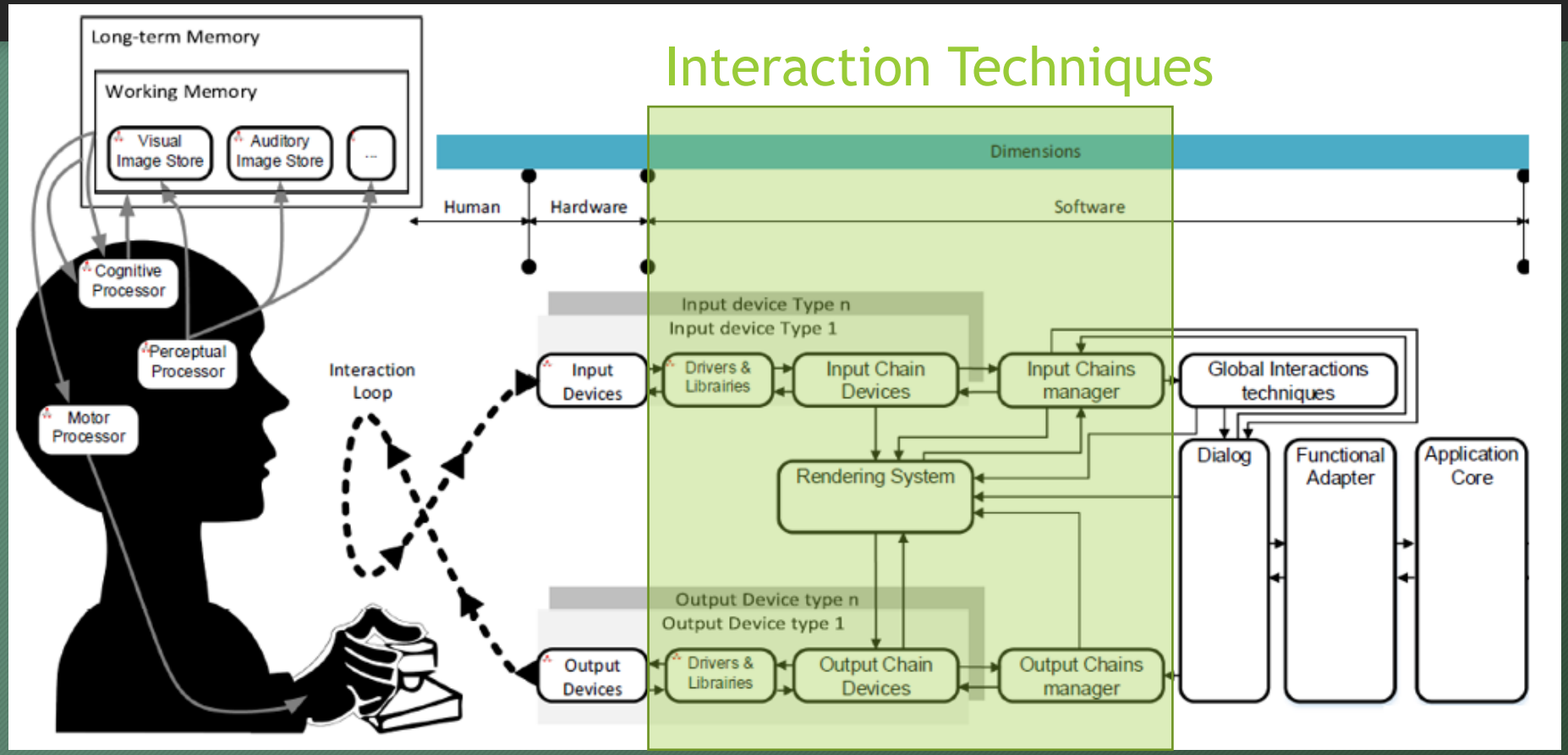
The HCI Loop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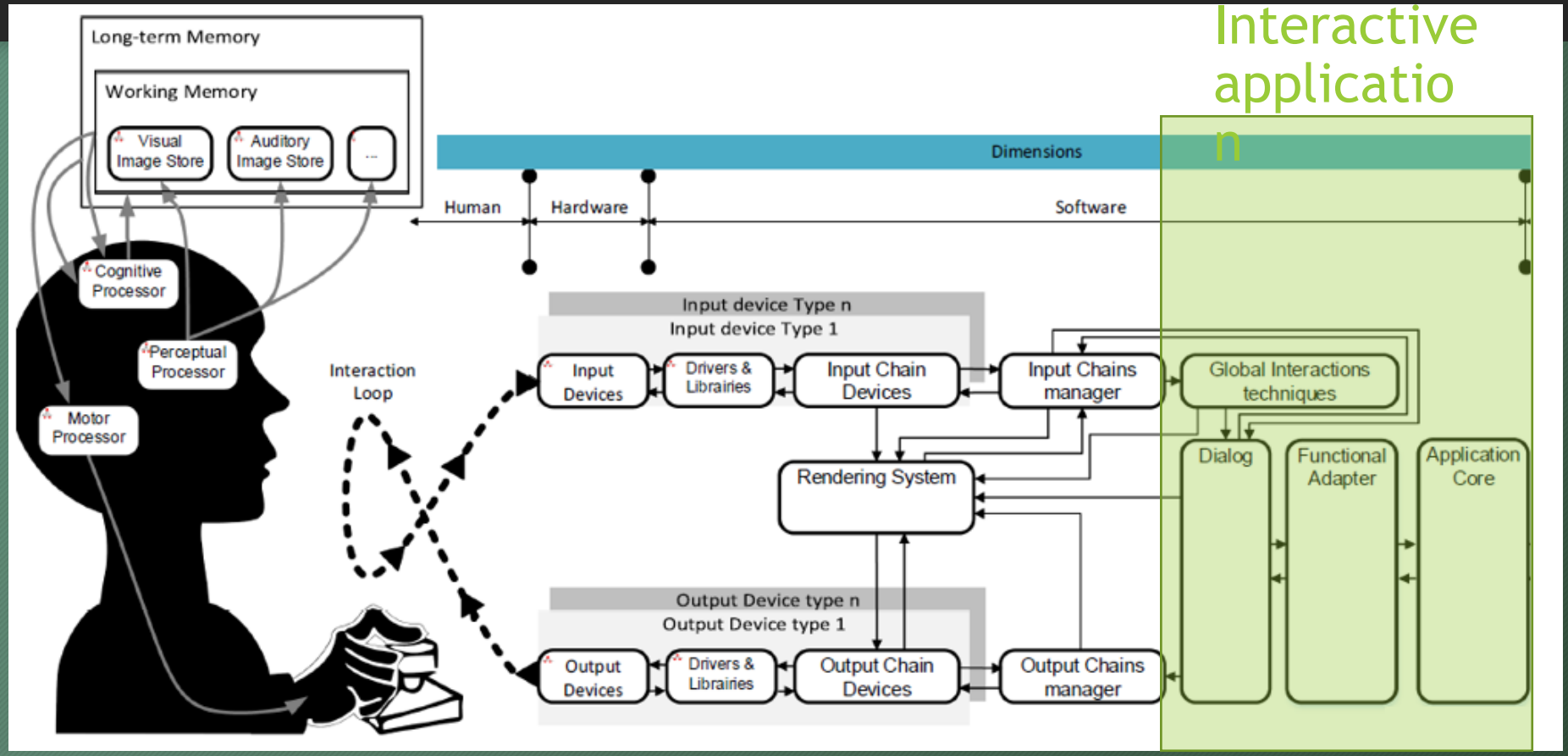
The HCI Loop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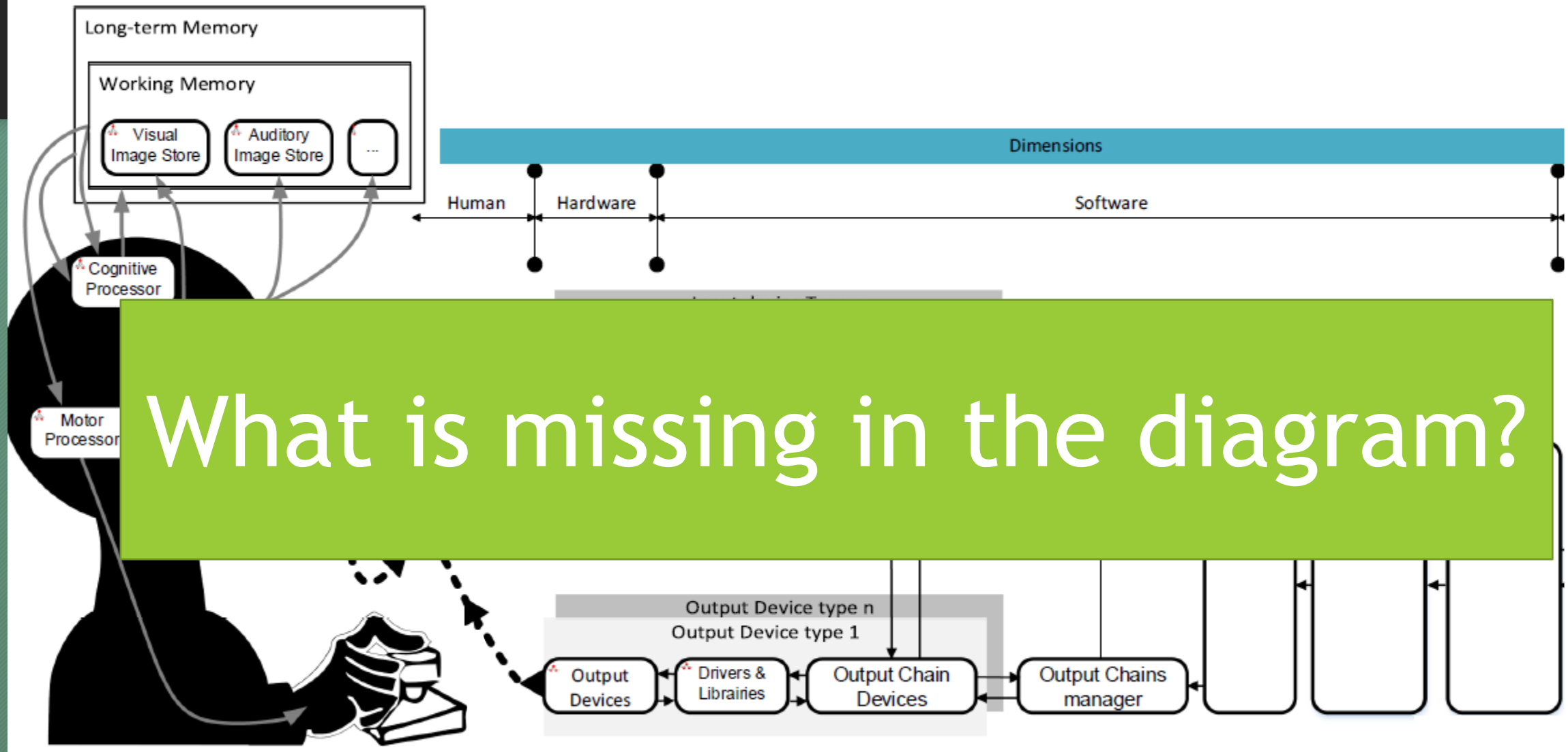
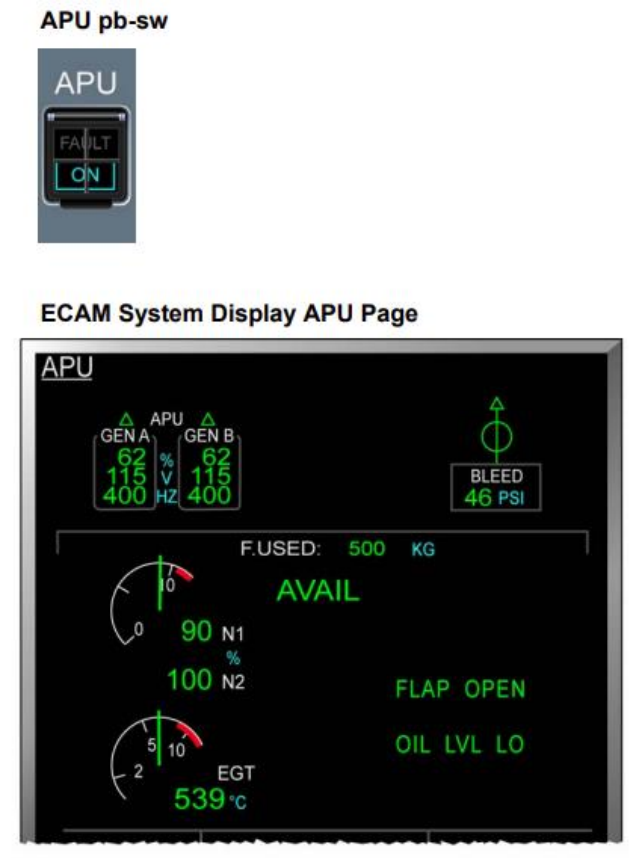
Output Chains manager
Interactive application



What is missing in the diagram?

Auxiliary Power Unit (APU ATA 49)

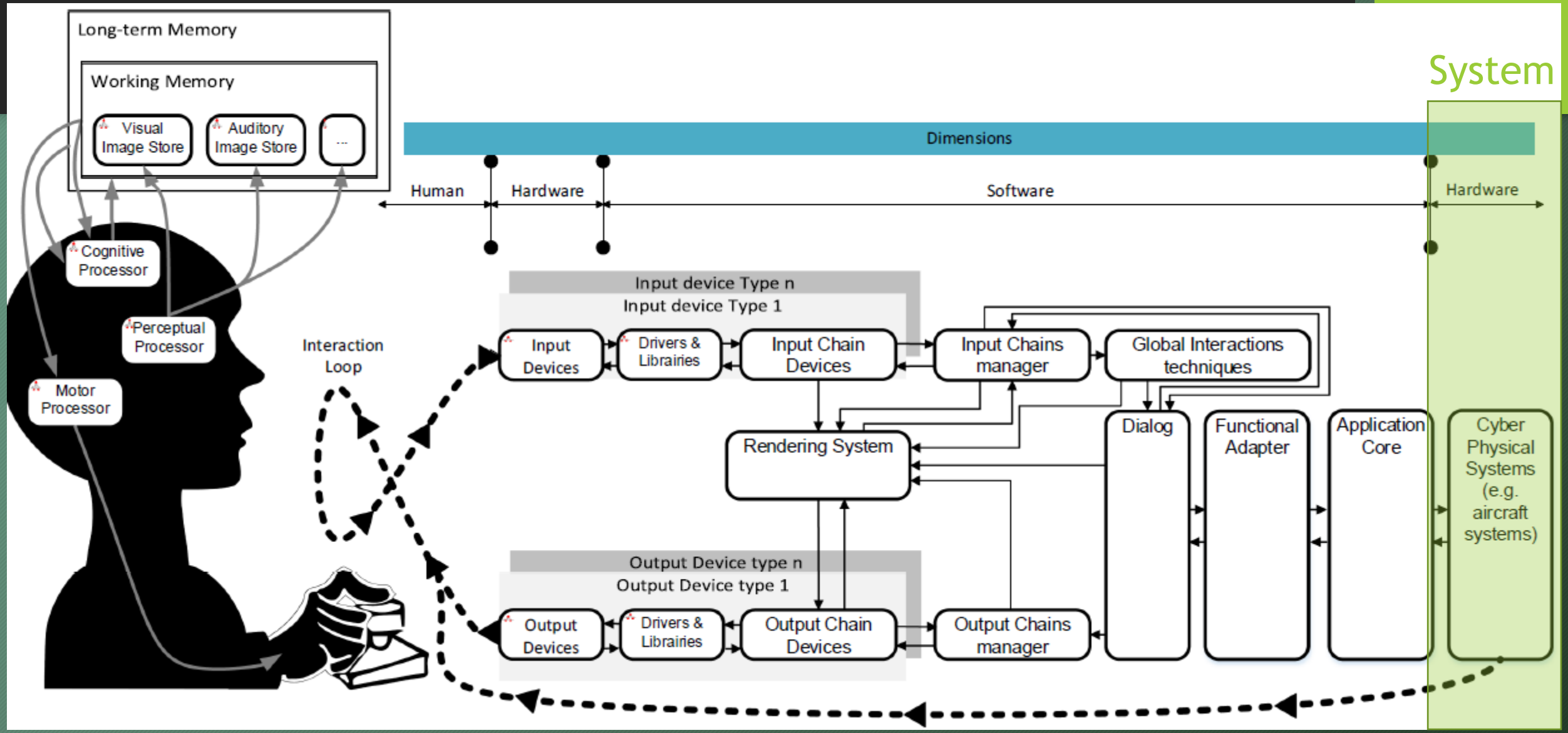


APU Display
APU SD Page

APU control
Overhead Panel

APU control
ECP

APU System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Input Chain Devices
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Global Interactions techniques
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Functional Adapter
Application Core
Cyber Physical Systems (e.g. aircraft systems)
Output Device type n
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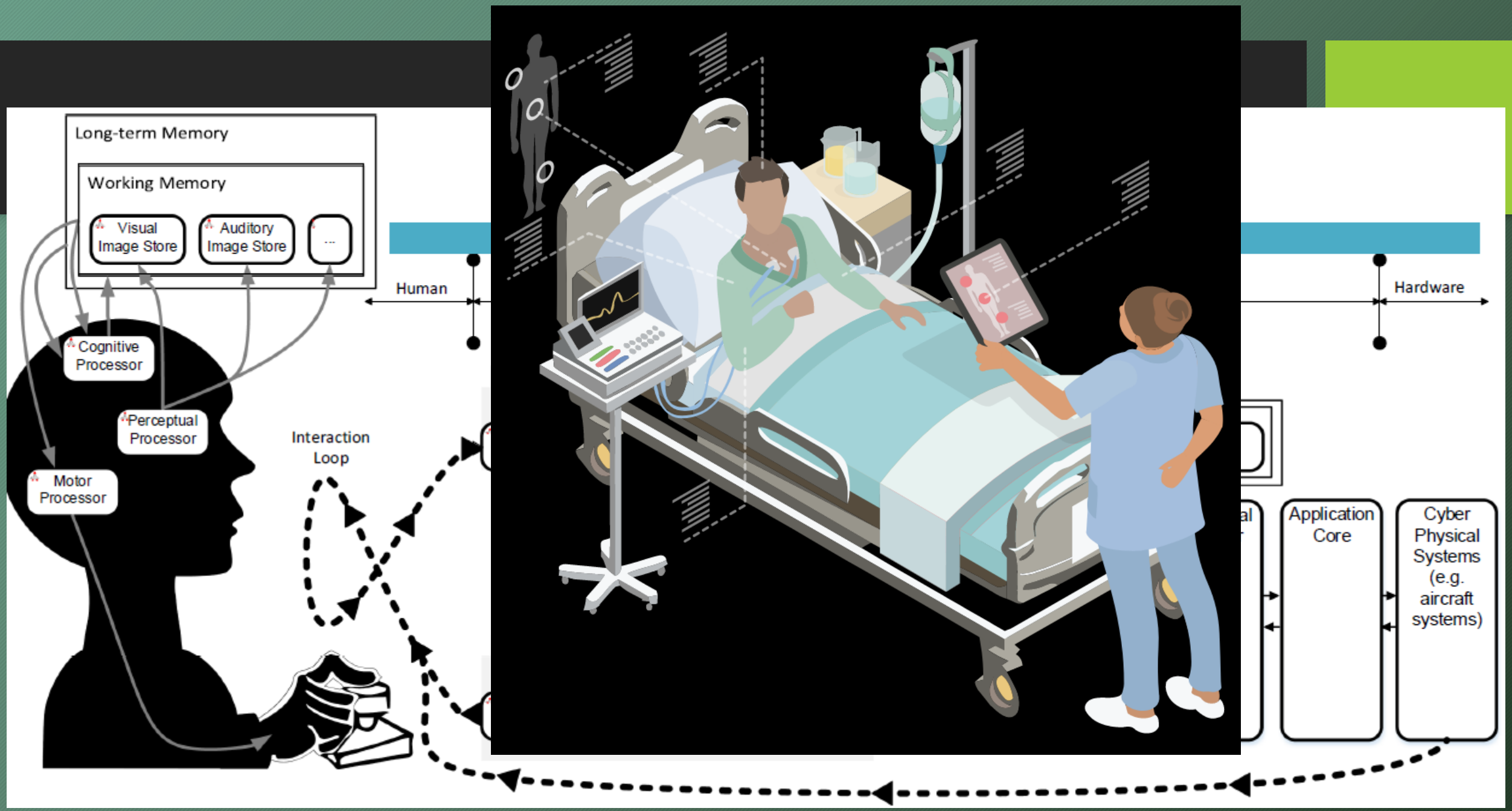
Drivers & Librairies
Output Chain Devices
Output Chains manager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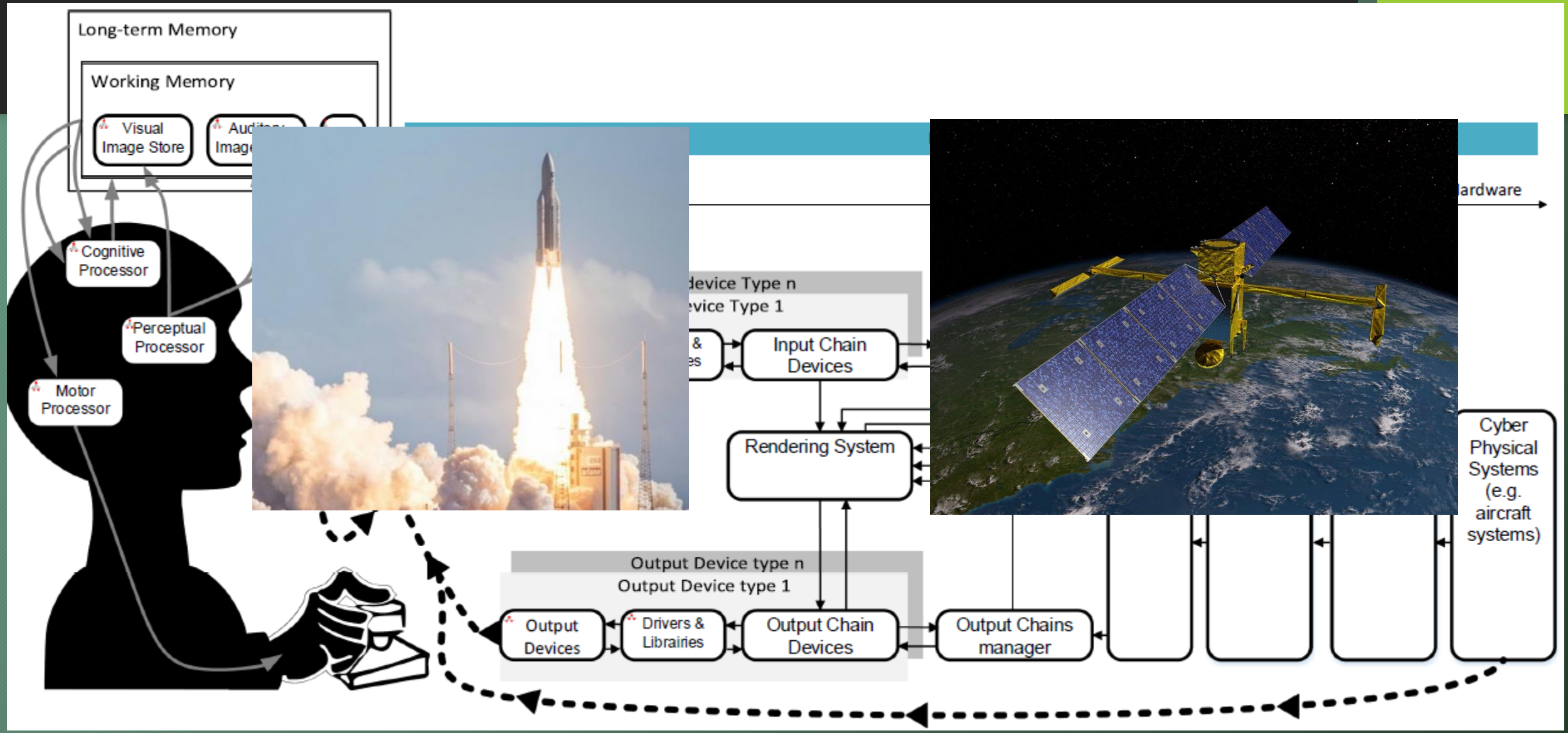
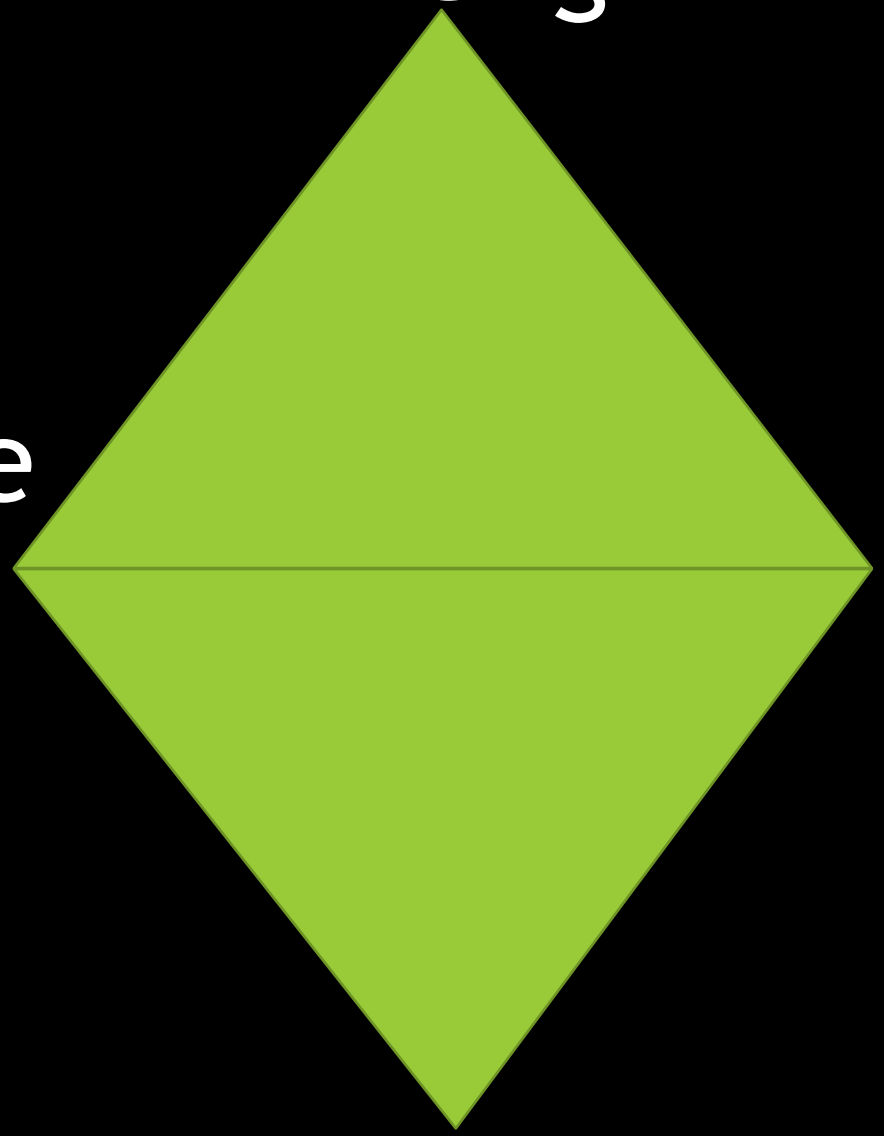
Requires co-location

Requires co-location



POISE-S Diamond



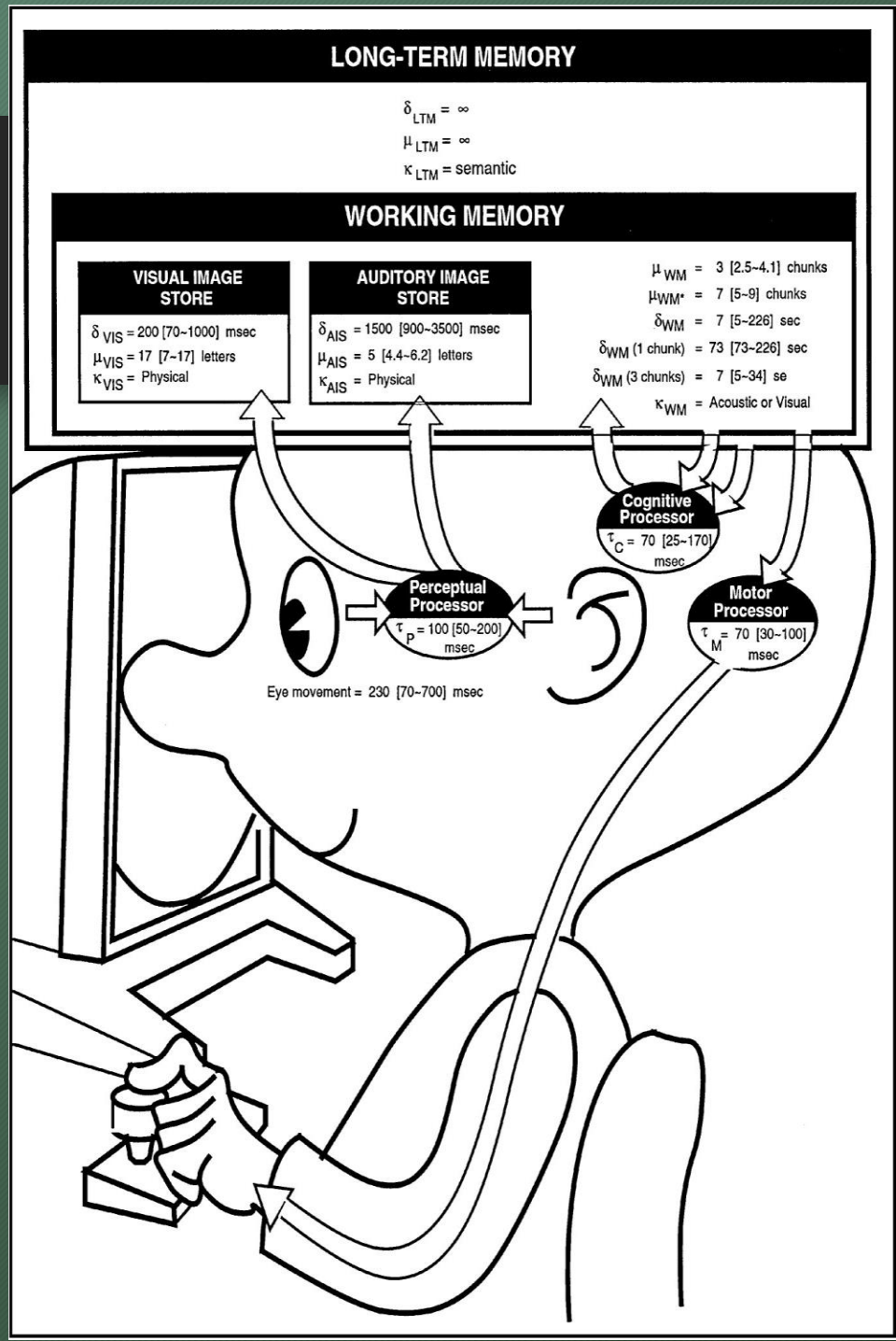
People

- Positive view on people
  - Do their best at work
  - Know the procedures
  - Work for optimisation of thoughput
  - Don’t make errors
- Negative view on people
  - Limited capabilities
  - Eroneous functioning by design
  - Conflicting interests with respect to work

People Behavior – HCI view

HCI Loop

- **Perception** of information from the environment
- **Cognition**: processing (and storing) of information (from memory or from the environment)
  - **Analysis** of information
  - **Decision** how to react
- **Action**: motoric behavior of the human



Parasuraman R, Sheridan TB, Wickens CD (2000). **A model for types and levels of human interaction with automation**. IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans 30(3):286–297.

Human Error through Actions and Outcomes

- Slips and lapses (un-intentional authorized actions, undesired outcome)
- Mistakes (intentional authorized actions, undesired outcome)
- Violations (intentional unauthorized action, desired outcome)
- Cognitive biases (intentional, authorized action, desired outcome (from the individual) undesired outcome (from other people perspective) - deviation from rationality

Reason, J. *(1990).* **Human error**. *Cambridge University Press1990*

Rasmussen, J. *(1983).* **Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models**. *Systems, Man and Cybernetics, IEEE Transactions on, (3), 257-266*

Human Error through Actions and Outcomes

- Slips and lapses (un-intentional authorized actions, undesired outcome)
  - Wrong key pressed on keyboard "b" instead of "v"
    - Un-intentional action "b" key pressed
    - Intentional action not performed "v" key pressed
  - Undesired outcome (e.g. letter "b" entered instead of "v")
- Mistakes (intentional authorized actions, undesired outcome)
- Violations (intentional unauthorized action, desired outcome)
- Cognitive biases (intentional, authorized action, desired outcome (from the individual) undesired outcome (from other people perspective) - deviation from rationality

Human Error through Actions and Outcomes

- Slips and lapses (un-intentional authorized actions, undesired outcome)
- Mistakes (intentional authorized actions, undesired outcome)
  - Intentional action (e.g. shut down engine presenting malfunction)
  - Un-intentional outcome (e.g. shut down the wrong engine)
- Violations (intentional unauthorized action, desired outcome)
- Cognitive biases (intentional, authorized action, desired outcome (from the individual) undesired outcome (from other people perspective) - deviation from rationality

Human Error through Actions and Outcomes

- Slips and lapses (un-intentional authorized actions, undesired outcome)
- Mistakes (intentional authorized actions, undesired outcome)
- Violations (intentional unauthorized action, desired outcome)
  - Intentional action (e.g. manipulate commands to land on water 2009, A320 US Airways 1549 landing on Hudson river)
  - Desired outcome (e.g. landing on water)
- Cognitive biases (intentional, authorized action, desired outcome (from the individual) undesired outcome (from other people perspective) - deviation from rationality

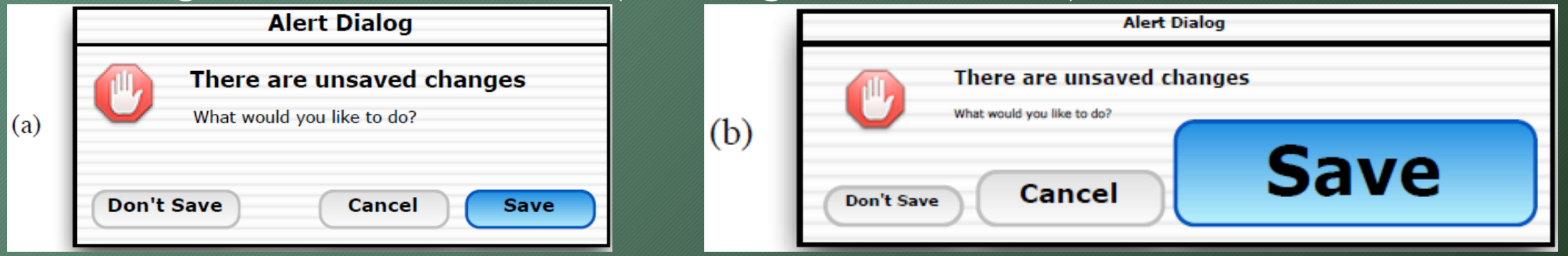
Check list for dual-engines down not applied

Human Error through Actions and Outcomes

- Slips and lapses (unintentional authorized actions, undesired outcome)
- Mistakes (intentional authorized actions, undesired outcome)
- Violations (intentional unauthorized action, desired or undesired outcome)
- Cognitive biases (intentional, authorized action, "desired" outcome (from the individual) undesired outcome (from other people perspective) - deviation from rationality
  - Intended action, desired outcome (e.g. cognitive tunneling)
  - Associated with slips, lapses, mistakes or violations (e.g. lapse for not noticing an alarm in attention tunneling or "unconscious" violations when under Dunning-Kruger effect)

Anchoring effect

- Anchoring is a cognitive bias where an individual depends too heavily on an initial piece of information offered (considered to be the "anchor") to make subsequent judgments during decision making
- Debiasing anchoring via interaction (adding time)
  - At interaction level of MIODMIT (input only)
  - Fine grain of interaction (slowing down mouse)



Renaud Blanch, Yves Guiard, Michel Beaudouin-Lafon: ***Semantic pointing: improving target acquisition with control-display ratio adaptation***. CHI 2004: 519-526

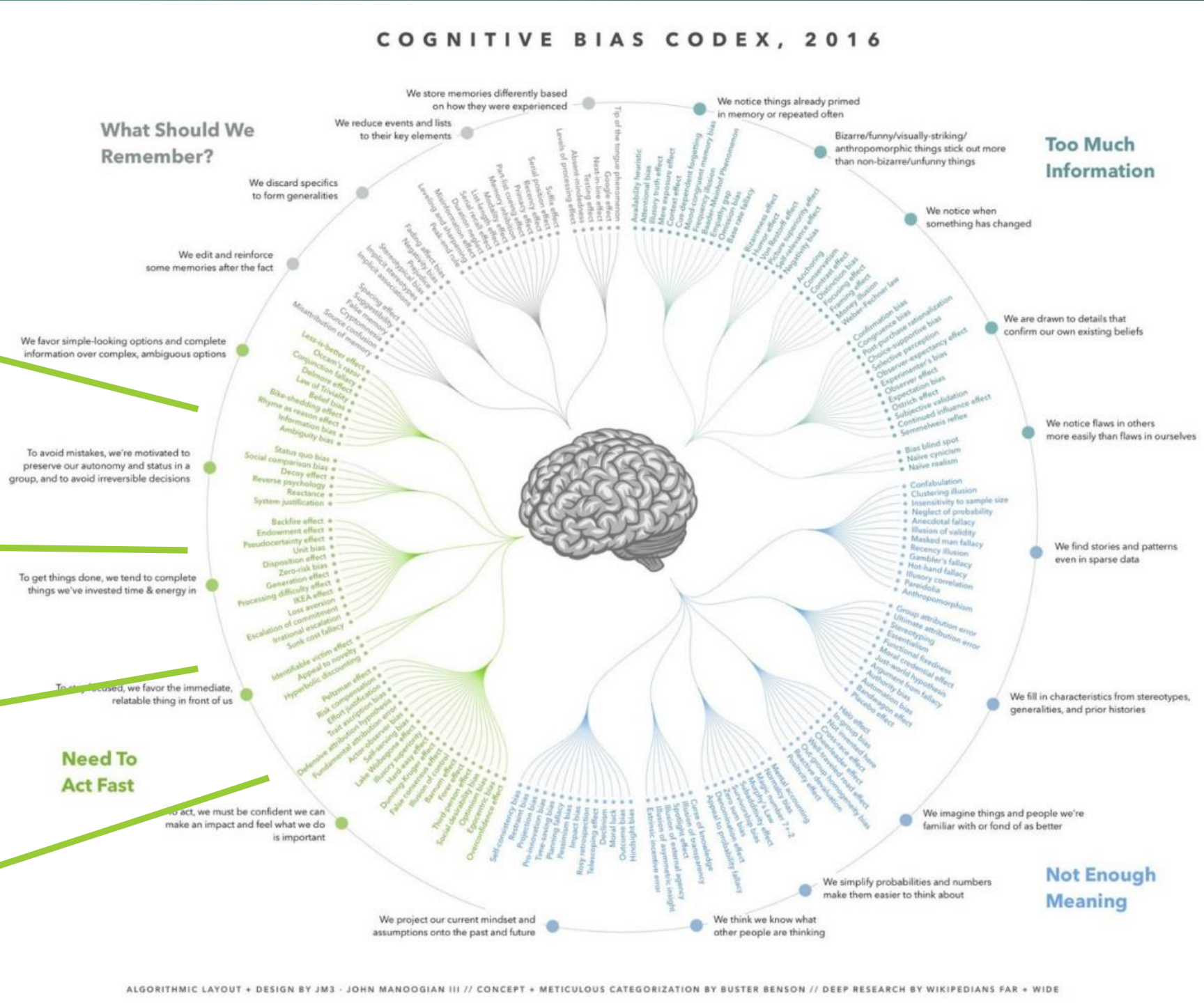
Training

Backfire Effect (arguing against someone wrong knowledge might reinforce their belief in that wrong knowledge)

John Henry effect (people over perform when establishing baseline)

Dunning Kruger Effect (less competent people overestimate their competence)

Hawthorne Effect (change behavior when aware of being observed)



Development

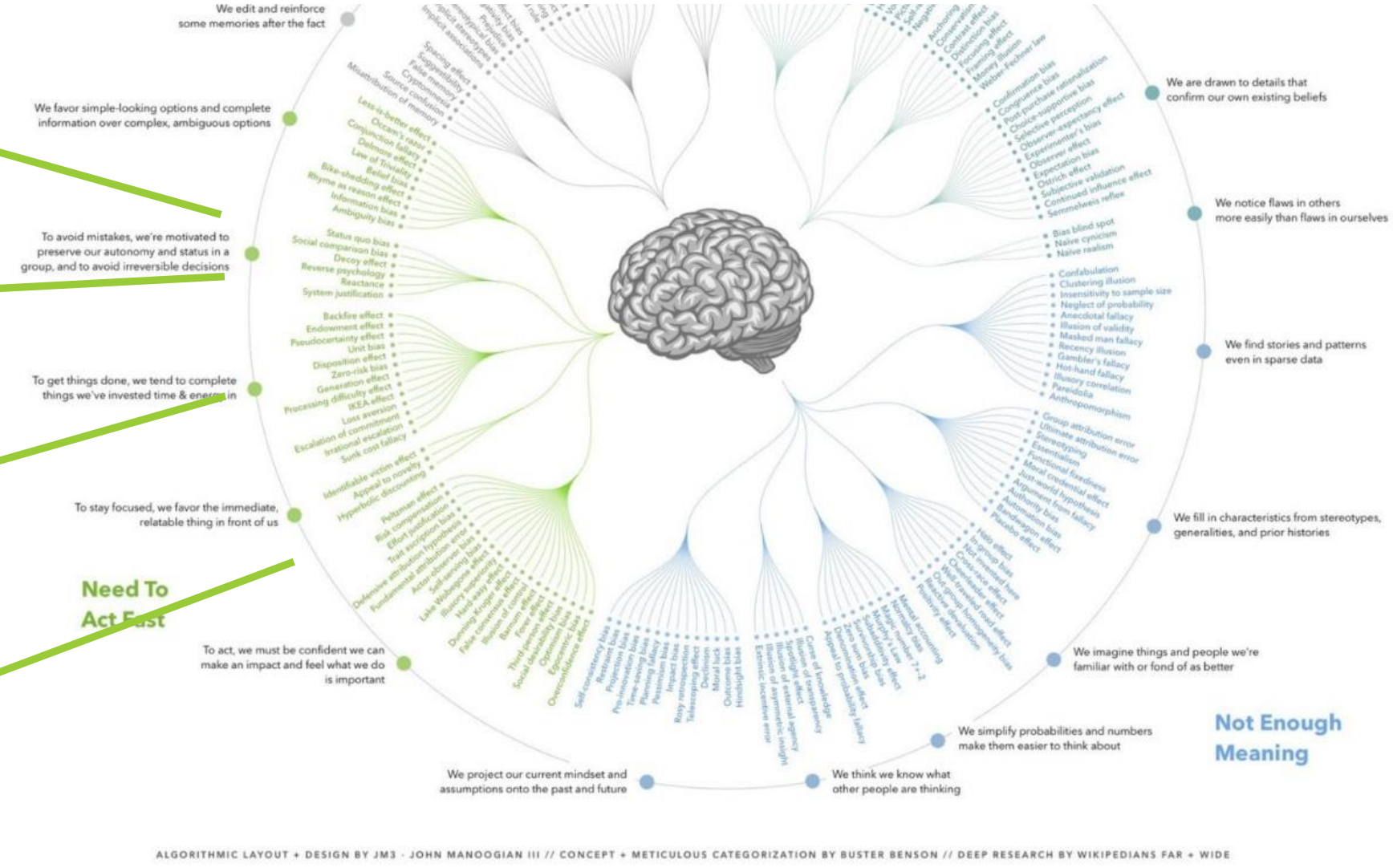
Anchoring Effect (over-confidence on an anchor point)

Planning fallacy (how wrong people estimate future tasks)

Bandwagon Effect (following what others are doing e.g. Python)

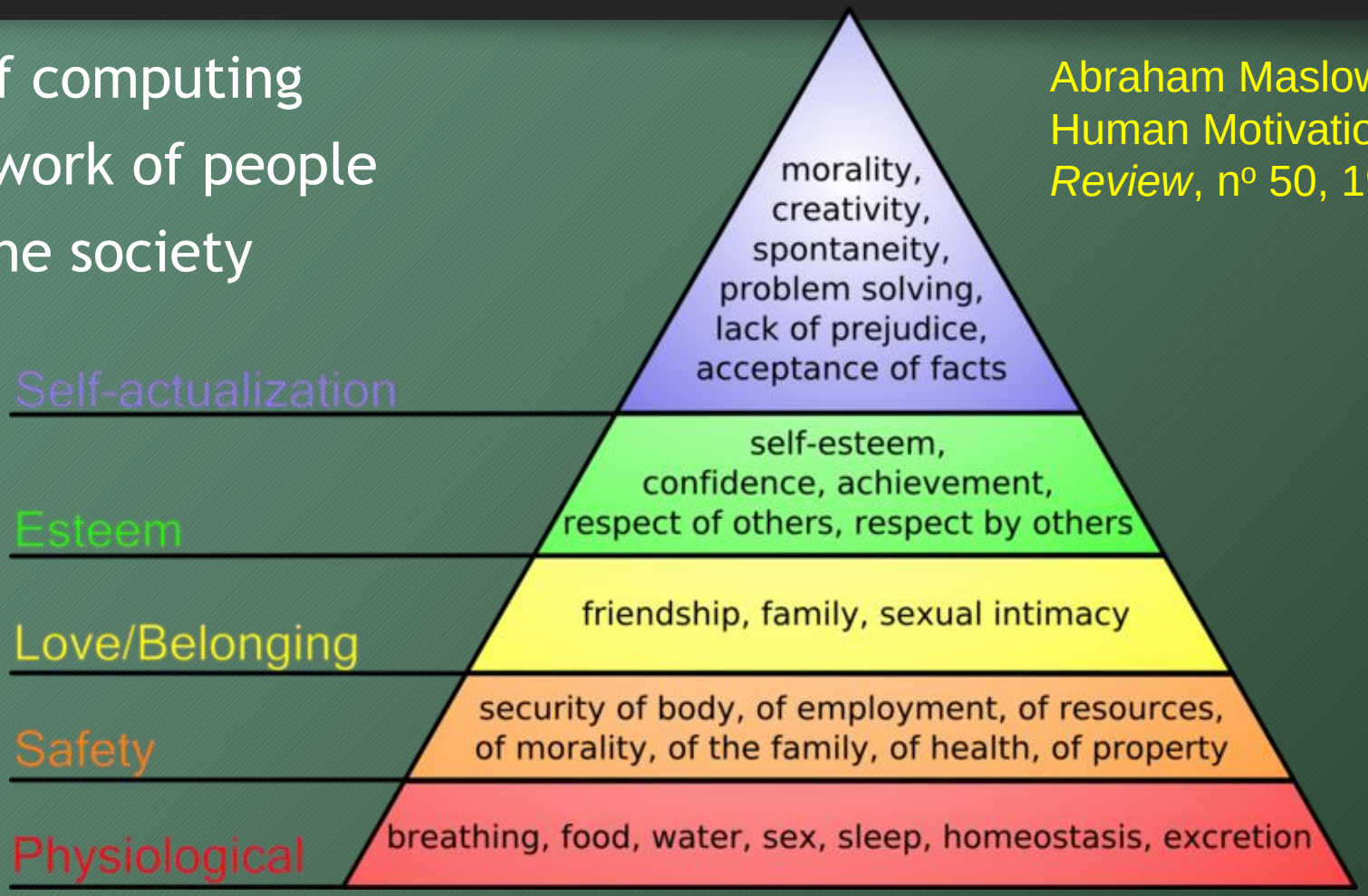
Dunning Kruger Effect (less competent people overestimate their competence)

R. Mohanani, I. Salman, B. Turhan, P. Rodríguez and P. Ralph, "**Cognitive Biases in Software Engineering: A Systematic Mapping Study**," in *IEEE Transactions on Software Engineering*, vol. 46, no. 12, pp. 1318-1339, 1 Dec. 2020, doi: 10.1109/TSE.2018.2877759 (37 cognitive biases)



People behavior (Social Computing)

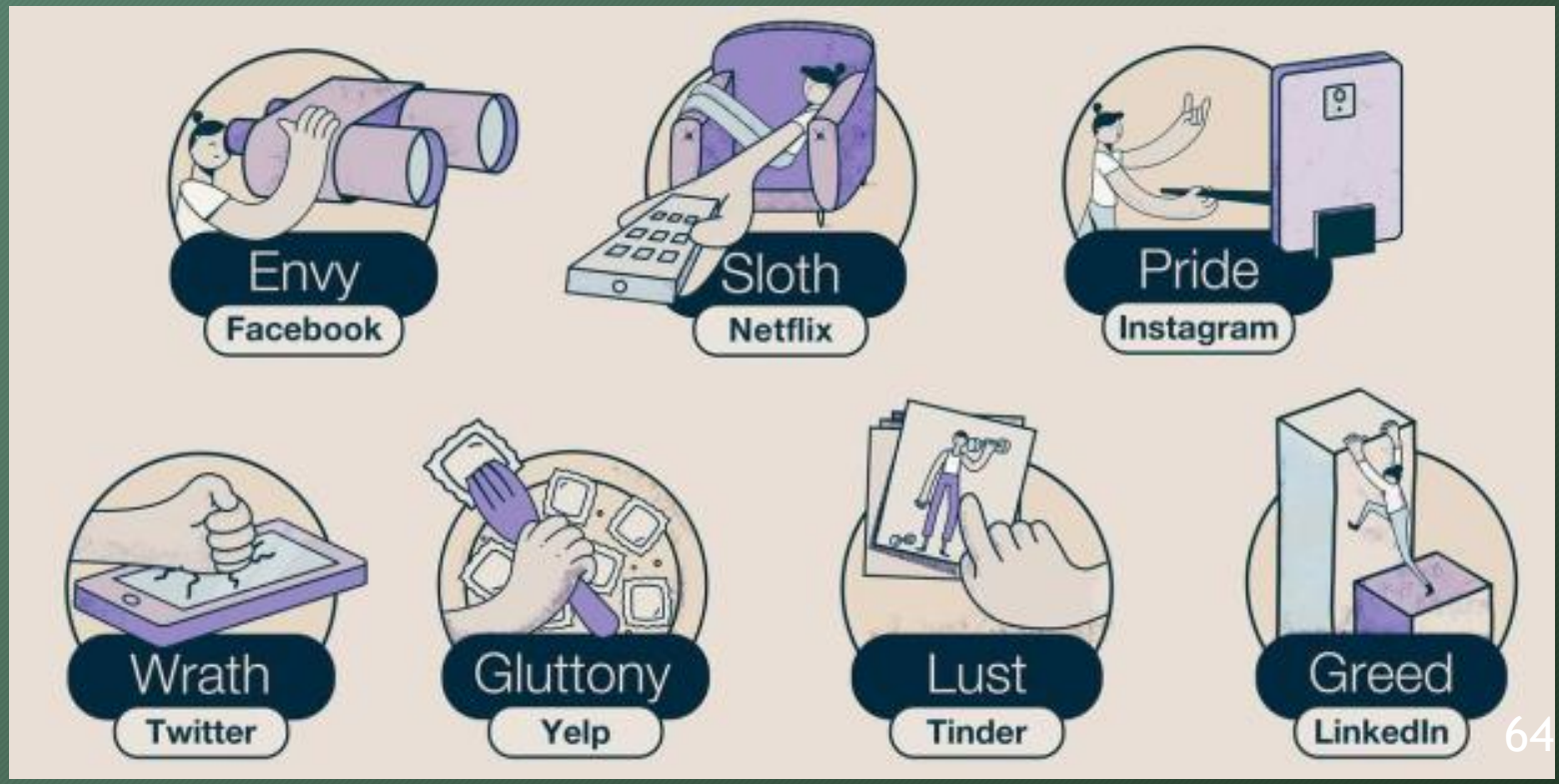
- Social aspect of computing
- Underlying network of people
- People inside the society



Abraham Maslow, "A Theory of Human Motivation", *Psychological Review*, nº 50, 1943, p. 370-396

People behavior (a-Social Computing)

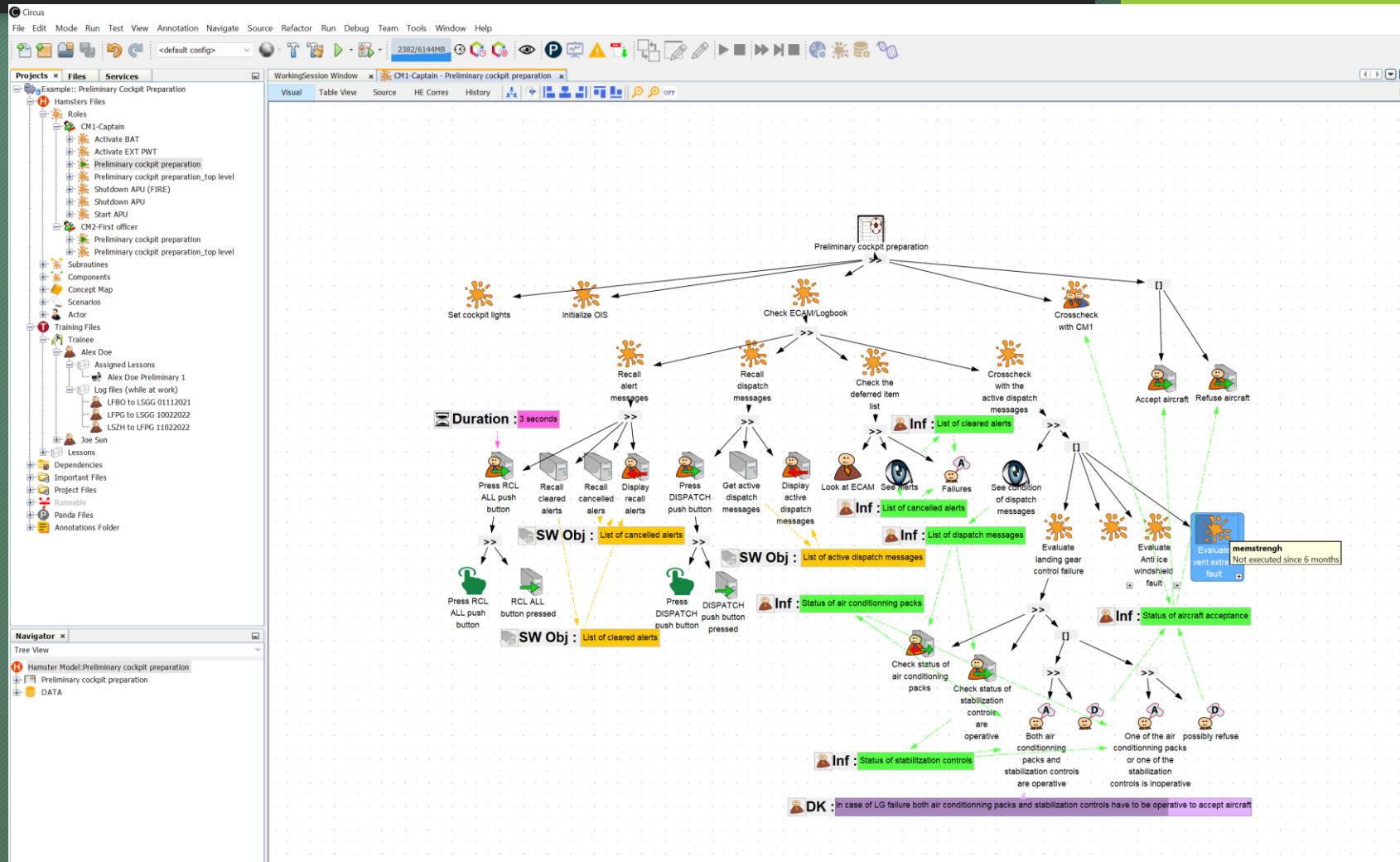
- Social aspect of computing
- Underlying network of people
- People inside the society
- "Bad" desires
- "Bad" needs



People – complex tasks

ELEFANT: a model**S**-based training tool

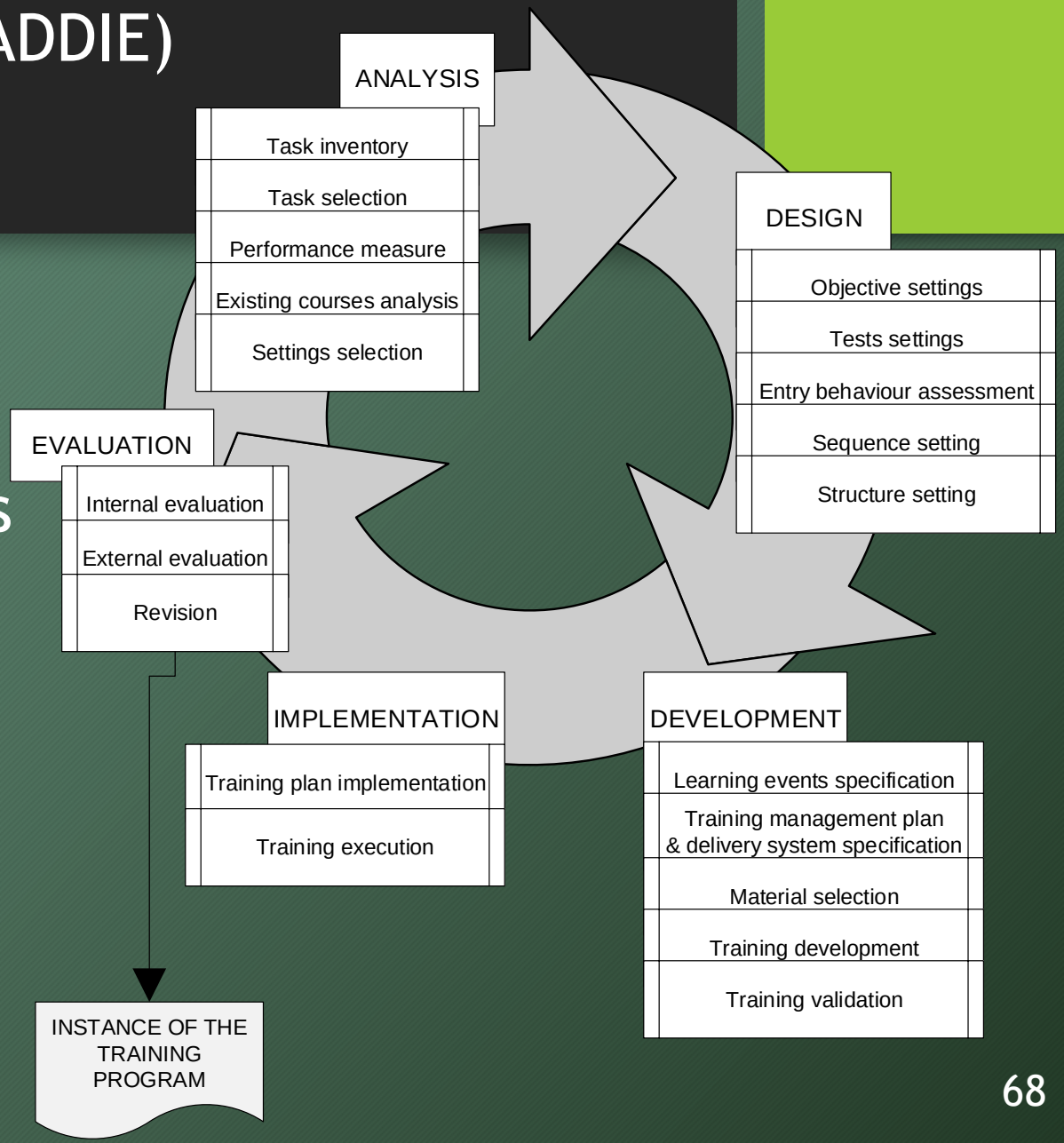
Engineering **L**earning and **E**ducation using **F**ormal tasks and systems **A**pproaches for **N**ext generation of **T**raining **S**ystems



People – training

Systematic Approaches to Training (ADDIE)

1. Set of development phases
2. Iterative and incremental
3. Precise elicitation of training needs
4. Based on objectives and results
5. Highly rely on task descriptions



Reiser, R. A. (2001). **A history of instructional design and technology**: Part II: A history of instructional design. Educational technology research and development, 49(2), 57–67.

U.S. Army Field Artillery School (1984). **A System Approach to Training** (Course Student textbook).

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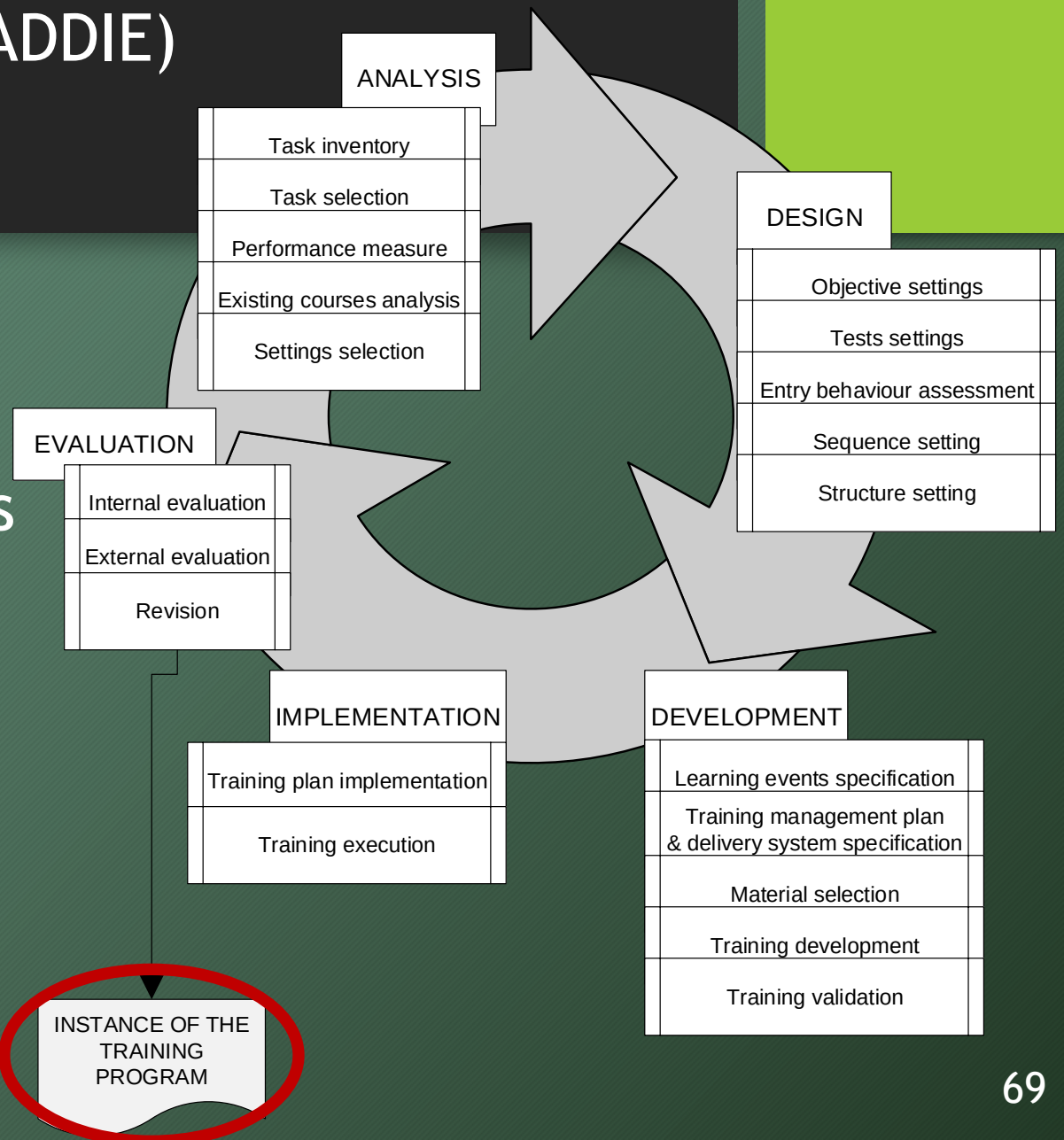

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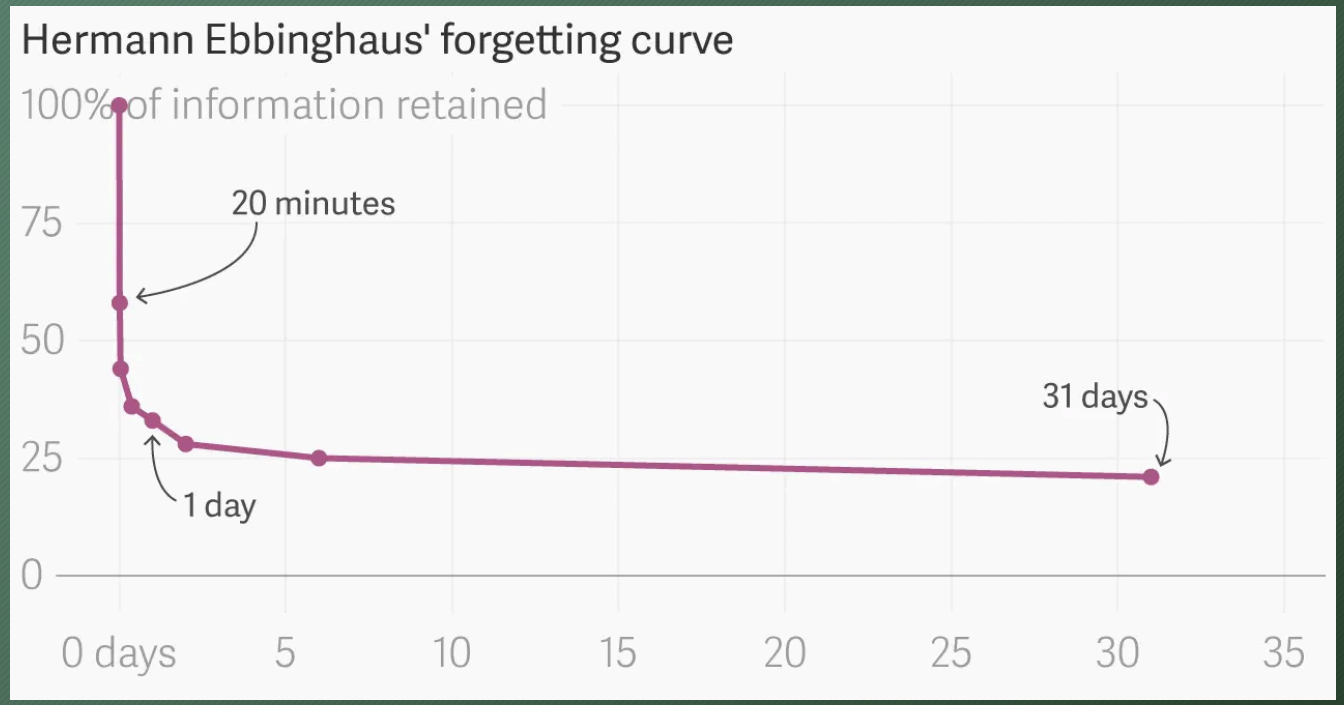
Limitations and problems

- Incomplete and unrealistic training

Fidelity affects training transfer

- Unaware training
  - Forgetting (each operator will evolve in a different context)
  - Impact of spacing
  - Errors during operations (learning wrong procedure)



Ebbinghaus H. 1913. **Memory: A contribution to experimental psychology**. H. A. Ruger & C. E. Bussenius, Trans. (1913).

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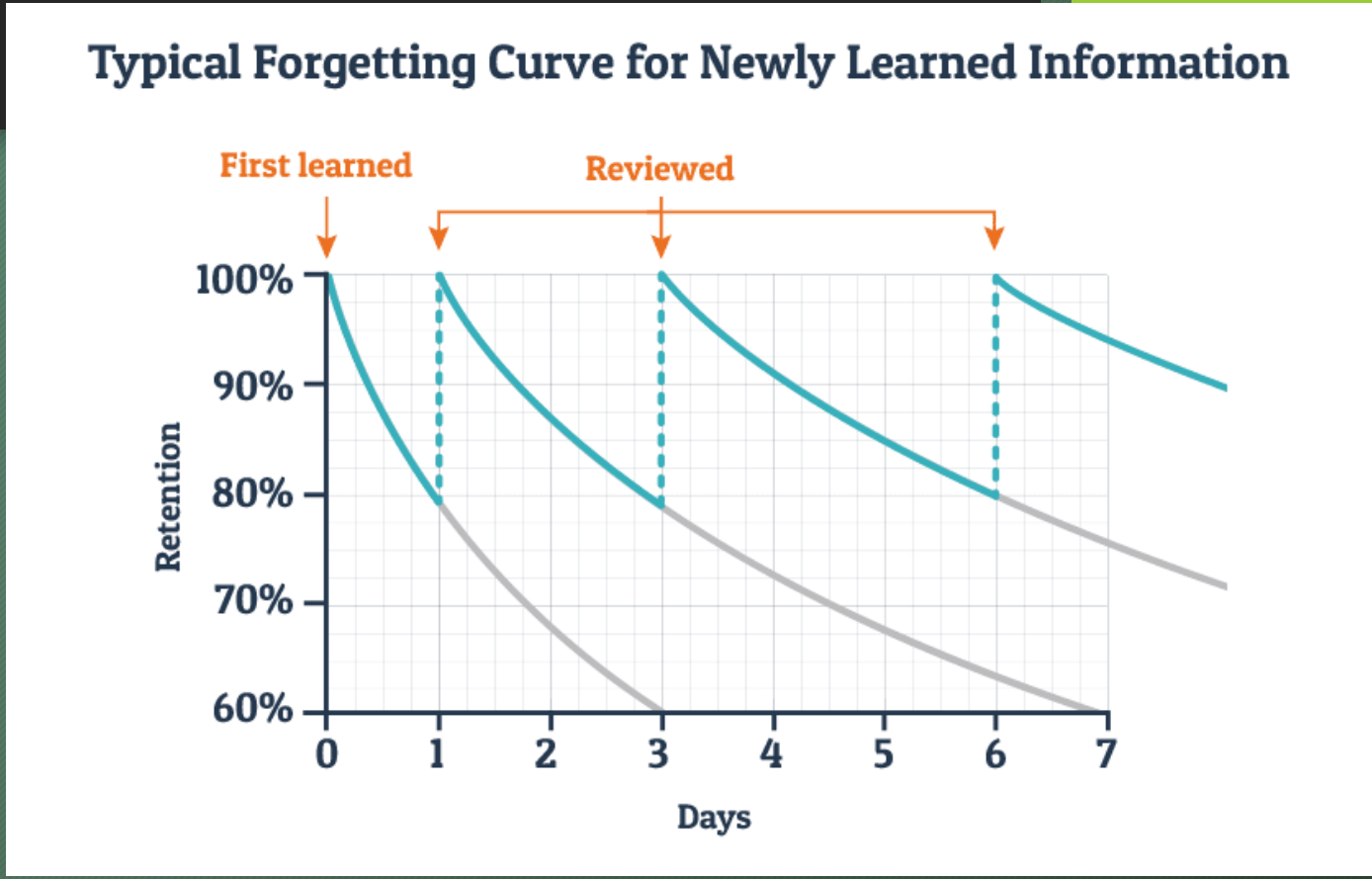

Ebbinghaus H. 1913. **Memory: A contribution to experimental psychology**. H. A. Ruger & C. E. Bussenius, Trans. (1913).

Limitations and problems

- Incomplete and unrealistic
- Fidelity issues with comput simulations
- Unaware training
- Over-expensive training
  - Parts of recurrent training are useless
  - Resources are booked whereas not always needed
  - Getting stuck on a given competency and thus no progress

Attribute	Manual	Training plan 1	Training plan 2
Training cost	$29.8 M	$27.1 M	$26.5 M
Pay protection	$2.3 M	$4.2 M	$0.2 M
New hires	$2.2 M	$2.5 M	$0.5 M
Cost without block hours	$34.3 M	$33.8 M	$27.2 M
Block-hour shortage	80,000 hrs	27,000 hrs	77,000 hrs
Block-hour-shortage cost	$11.2 M	$3.8 M	$10.8 M
Total cost	$45.5 M	$37.6 M	$38.0 M

Gang Yu, Julian Pachon, Benjamin G. Thengvall, Darryal Chandler, Al Wilson. **Optimizing Pilot Planning and Training for Continental Airlines**. Interfaces 34(4): 253-264 (2004)

ECSS-Q-20B
8 March 2002

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDA

ECSS-Q-20B

Space product assurance

Quality assurance

4.5 Personnel training and certification

4.5.1

The supplier shall establish a documented training programme for QA personnel and all other personnel whose performance determines or affects product quality.

4.5.2

Operators performing critical processes (as defined in ECSS-Q-70) shall be trained and certified by internal or external training programmes accepted by the customer, or can demonstrate a regular and satisfactory use of the related skills.

4.5.3

Those inspecting or controlling critical processes, or performing non-destructive testing and evaluation, shall be trained and certified according to national or international training programmes and standards accepted by the customer, or can demonstrate a regular and satisfactory use of the related skills.

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

A concrete example from CSG

- Non présenté

Conclusion and perspectives

- The systems are complex as soon as a human operator is involved
- Complexity is polymorph and within each component
  - Organization
  - People
  - Interactive systems
  - Environment (in the command and control and for the underlying system)
- POISES components should be co-designed
  - Interactive systems, interactions and interfaces
  - Selection, licencing and recurrent training of operators
  - Procedures, tasks and organization of work
- Multiple properties conflicting
  - What is the usability improvement of the interactive system ?
  - What is the dependability level of a new interactive systems (how frequent failures will be?) ?
  - How training will be affected (for a mission and across multiple missions) ?
  - Do we need User Experience in control rooms ?

e.g. impact of humidity on short term and long term reliability

Special thanks to colleagues

Célia Martinie, David Navarre & Eric Barboni (ICS)
Yannick Deleris & Christine Gris (Airbus)
Andy Cockburn & Carl Gutwin (International)
Sandra Steere, Flight Safety team at CSG and Erwann Poupart

Recent PhD students: Elodie Bouzekri, Alex Canny

Thank you very much … for the invitation and for your attention

Questions?

The importance of tasks descrioptions

European Aviation Safety Agency

Certification Specifications for Large Aeroplanes

CS-25

Amendment 4
27 December 2007

CS–25 BOOK 1

SUBPART F – EQUIPMENT

GENERAL

CS 25.1301 Function and installation
(See AMC 25.1301)

Each item of installed equipment must –

(a) Be of a kind and design appropriate to its intended function;

(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors. (See AMC 25.1301(b).)

(c) Be installed according to limitations specified for that equipment.

[Amdt. No.:25/2]

CS 25.1302 Installed systems and equipment for use by the flight crew
(See AMC 25.1302)

This paragraph applies to installed equipment intended for flight-crew members' use in the operation of the aeroplane from their normally seated positions on the flight deck. This installed equipment must be shown, individually and in combination with other such equipment, to be designed so that qualified flight-crew members trained in its use can safely perform their tasks associated with its intended function by meeting the following requirements:

(a) Flight deck controls must be installed to allow accomplishment of these tasks and information necessary to accomplish these tasks must be provided.

(b) Flight deck controls and information intended for flight crew use must:

(1) Be presented in a clear and unambiguous form, at resolution and precision appropriate to the task.

(2) Be accessible and usable by the flight crew in a manner consistent with the urgency, frequency, and duration of their tasks, and

(3) Enable flight crew awareness, if awareness is required for safe operation, of the effects on the aeroplane or systems resulting from flight crew actions.

(c) Operationally-relevant behaviour of the installed equipment must be:

(1) Predictable and unambiguous, and

(2) Designed to enable the flight crew to intervene in a manner appropriate to the task.

(d) To the extent practicable, installed equipment must enable the flight crew to manage errors resulting from the kinds of flight crew interactions with the equipment that can be reasonably expected in service, assuming the flight crew is acting in good faith. This sub-paragraph (d) does not apply to skill-related errors associated with manual control of the aeroplane.

[Amdt. No.:25/3]

CS 25.1303 Flight and navigation instruments

(a) The following flight and navigation instruments must be installed so that the instrument is visible from each pilot station:

(1) A free-air temperature indicator or an air-temperature indicator which provides indications that are convertible to free-air temperature.

(2) A clock displaying hours, minutes, and seconds with a sweep-second pointer or digital presentation.

(3) A direction indicator (non-stabilised magnetic compass).

(b) The following flight and navigation instruments must be installed at each pilot station:

(1) An airspeed indicator. If airspeed limitations vary with altitude, the indicator must have a maximum allowable airspeed indicator showing the variation of V_{MO} with altitude.

(2) An altimeter (sensitive).

(3) A rate-of-climb indicator (vertical speed).

(4) A gyroscopic rate of turn indicator combined with an integral slip-skid indicator (turn-and-bank indicator) except that only a slip-skid indicator is required on aeroplanes with a third attitude instrument system usable through flight attitudes of 360° of pitch and roll, which is powered from a source independent of the electrical generating system and continues reliable operation for a minimum of 30 minutes after total failure of the electrical generating system, and is installed in accordance with CS 25.1321 (a).

CS–25 BOO

SUBPART F – EQU

GENERAL

CS 25.1301 Function and installation
(See AMC 25.1301)

Each item of installed equipment must –

(a) Be of a kind and design appropriate to its intended function;

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(c) Be installed according to limitations specified for that equipment.

[Amdt. No.:25/2]

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[Amdt. No.:25/3]

CS 25.1303 Flig
instr

(a) The following
instruments must be insta
is visible from each pilot s

(1) A free-air t
air-temperature indi
indications that are
temperature.

(2) A clock d
and seconds with a
digital presentation.

(3) A direction
magnetic compass).

(b) The following
instruments must be instal

(1) An airspee
limitations vary with a
have a maximum allo
showing the variation c

(2) An altimete

(3) A rate-of-clim
speed).

(4) A gyroscopic
combined with an integr
(turn-and-bank indicator)
skid indicator is required
third attitude instrument
flight attitudes of 360° of p
powered from a source
electrical generating sy
reliable operation for a m
after total failure of the
system, and is installed i
25.1321 (a).

1–F–1

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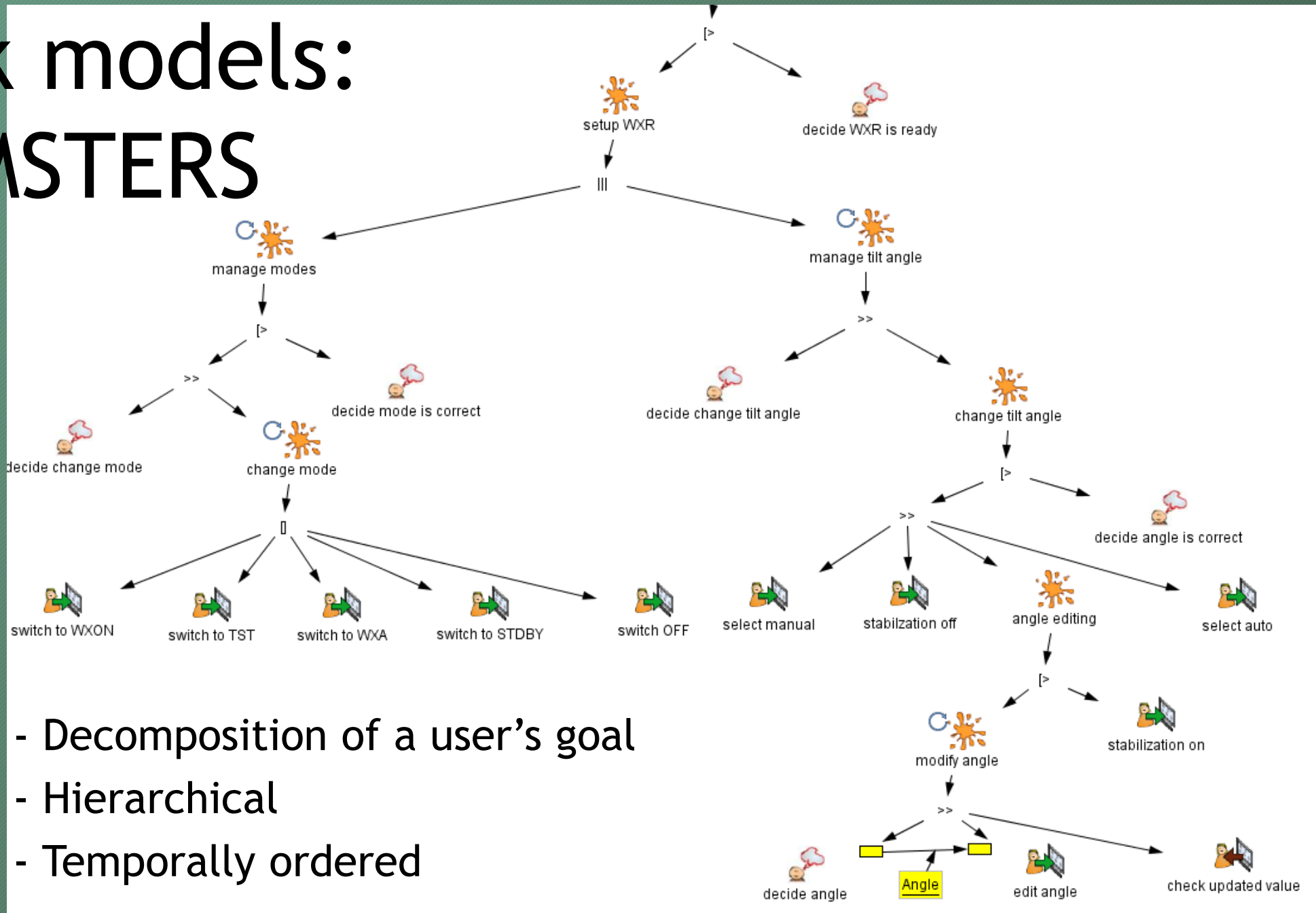
Goals of HAMSTERS

- Remain similar to the main task modeling tools
  - Factorization of operators
  - Handle low-level tasks (related to interaction techniques)
- Extends expressive power of existing tools
  - Handle object information (preconditions, processing, …) (ECCE 2013)
  - Support structuring (INTERACT 2011)
  - Support reuse and components (HCSE 2014)
- Make it possible to
  - Connect to a system model (TAMODIA 2007/AMBOSS)
  - Co-execution of models (EICS 2010)
  - Co-execution of tasks with an interactive application (EICS 2015)
  - Support performance evaluation (EICS 2009)
  - Formally check the compatibility of tasks and system models (EHCI 1995, IwC 1997)
  - Support training (EICS 2011)

Task models: HAMSTERS



- Decomposition of a user's goal
- Hierarchical
- Temporally ordered

Martinie, Palanque et al. 2013. **Extending Procedural Task Models by Explicit and Systematic Integration of Objects, Knowledge and Information.** In *European Conference on Cognitive Ergonomics 2013 (ECCE)*. . ACM, ECCE '13, 23, 1-10.

Célia Martinie, Philippe Palanque, Elodie Bouzekri, Andy Cockburn, Alexandre Canny, Eric Barboni: **Analysing and Demonstrating Tool-Supported Customizable Task Notations.** Proc. ACM Hum. Comput. Interact. 3(EICS): 12:1-12:26 (2019)