The Seventeenth International Conference on Future Computational Technologies and Applications
FUTURE COMPUTING 2025
April 06, 2025 to April 10, 2025 - Valencia, Spain

Fugacity Phase Transition and Hyper-Heuristic Convergence for AI-centric Conceptual Estimating

Presenter: Steve Chan

Thank you to the reviewers and conference sponsors.

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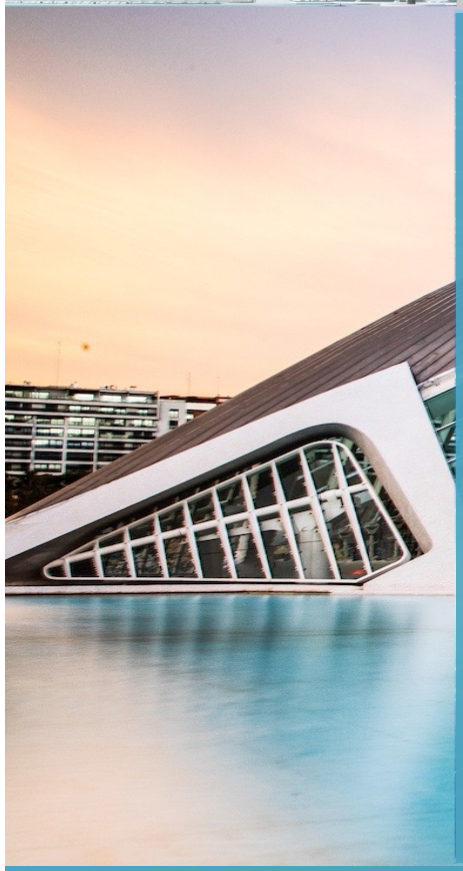

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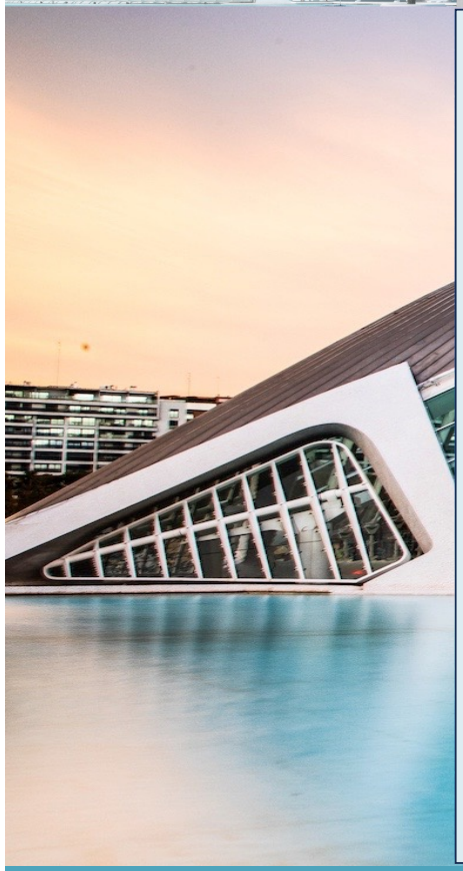

- **Build me a Transparency, Explainability, and Accountability (STEA)-centric AI System (AIS)!**
- **Socio-Technical System (STS), STEA, and Interpretability & Explainability (I&E) (SSI) considerations for AIS:**
  - STS biases may be systemic.
  - STEA and "black box" elements may create "glass ceiling" effects (and oblige withdrawal from the market)
  - To leverage ML on ML, I&E is needed.
- **There is a heightened expectation for STS/STEA (in general) and I&E (in particular).**
  - U.S. National Institute of Standards and Technology (NIST) Special Publication 1270 "Towards a Standard for Identifying and Managing Bias in Artificial Intelligence;"
  - Association for Computing Machinery (ACM) "Principles for Algorithmic Transparency and Accountability;"
  - Institute of Electrical and Electronics Engineers (IEEE) Standard for Transparency of Autonomous Systems (P7001), among others;
- **Yet, a substantive portion of AI researchers opine that "a deeper network is better for decision-making than a shallow network. So, what is to be done?**
  - Perhaps, use an SSI-oriented architecture?
  - Perhaps, use more robust (less biased) counterpoisings, such as Multi-Attribute Decision-Making (MADM) with Multi-Objective Decision-Making (MODM) and Subjective Methods (SMs) with Objective Methods (OMs)?


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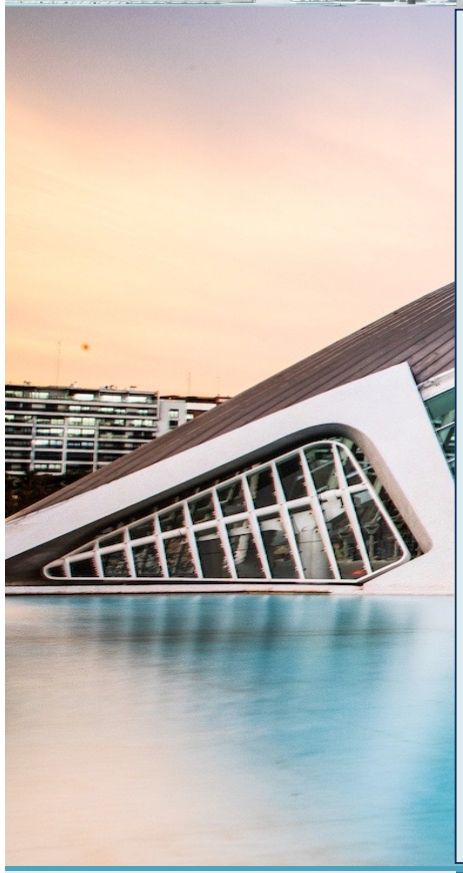
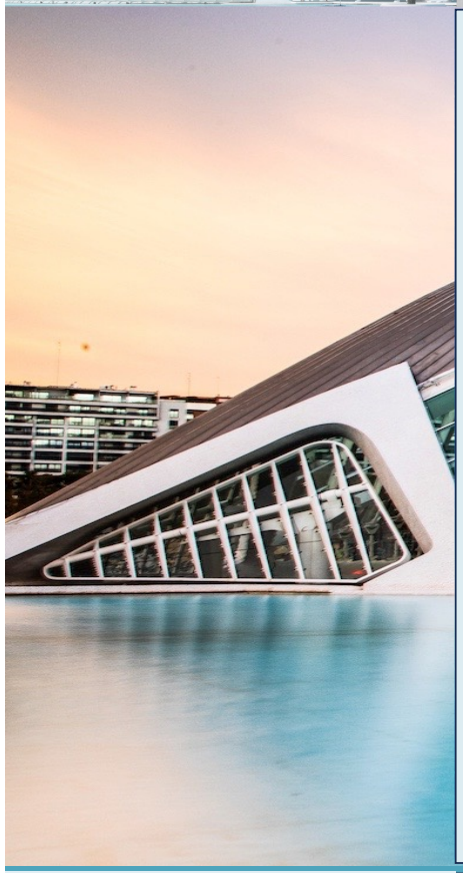
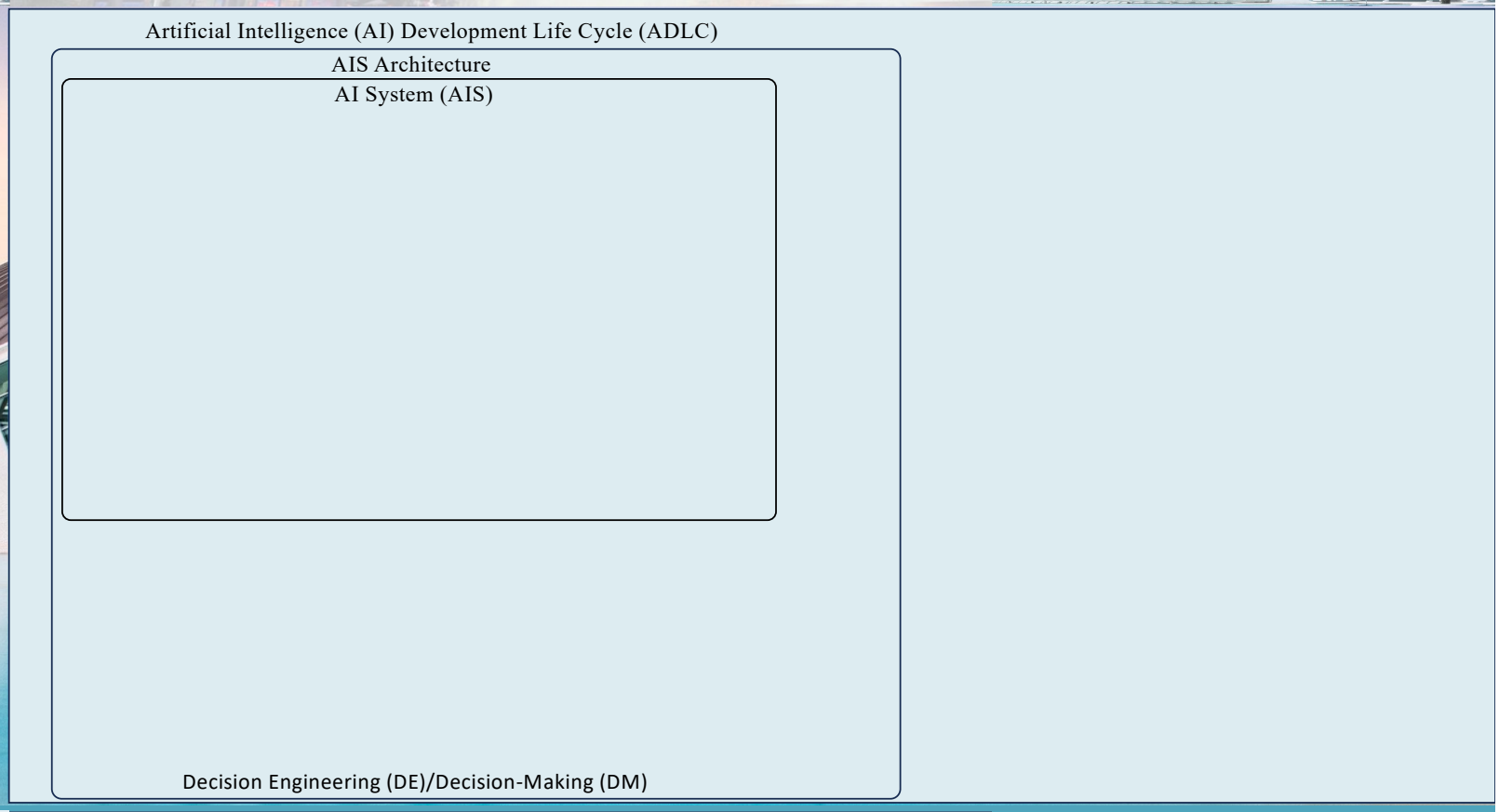
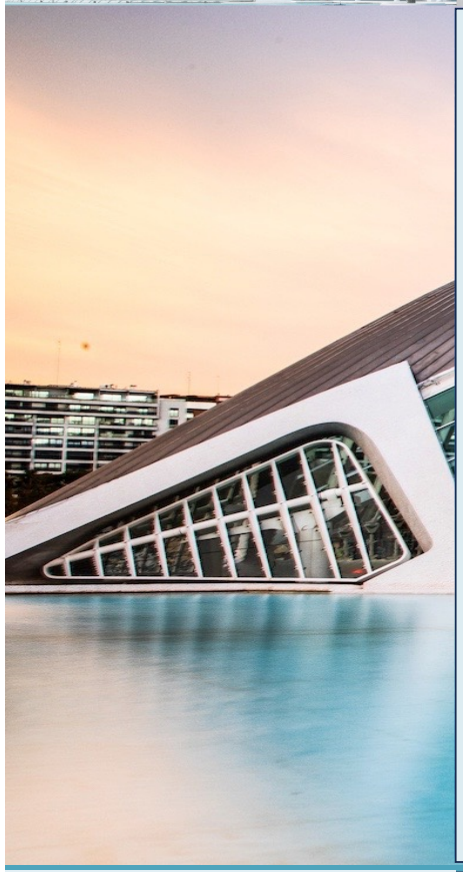


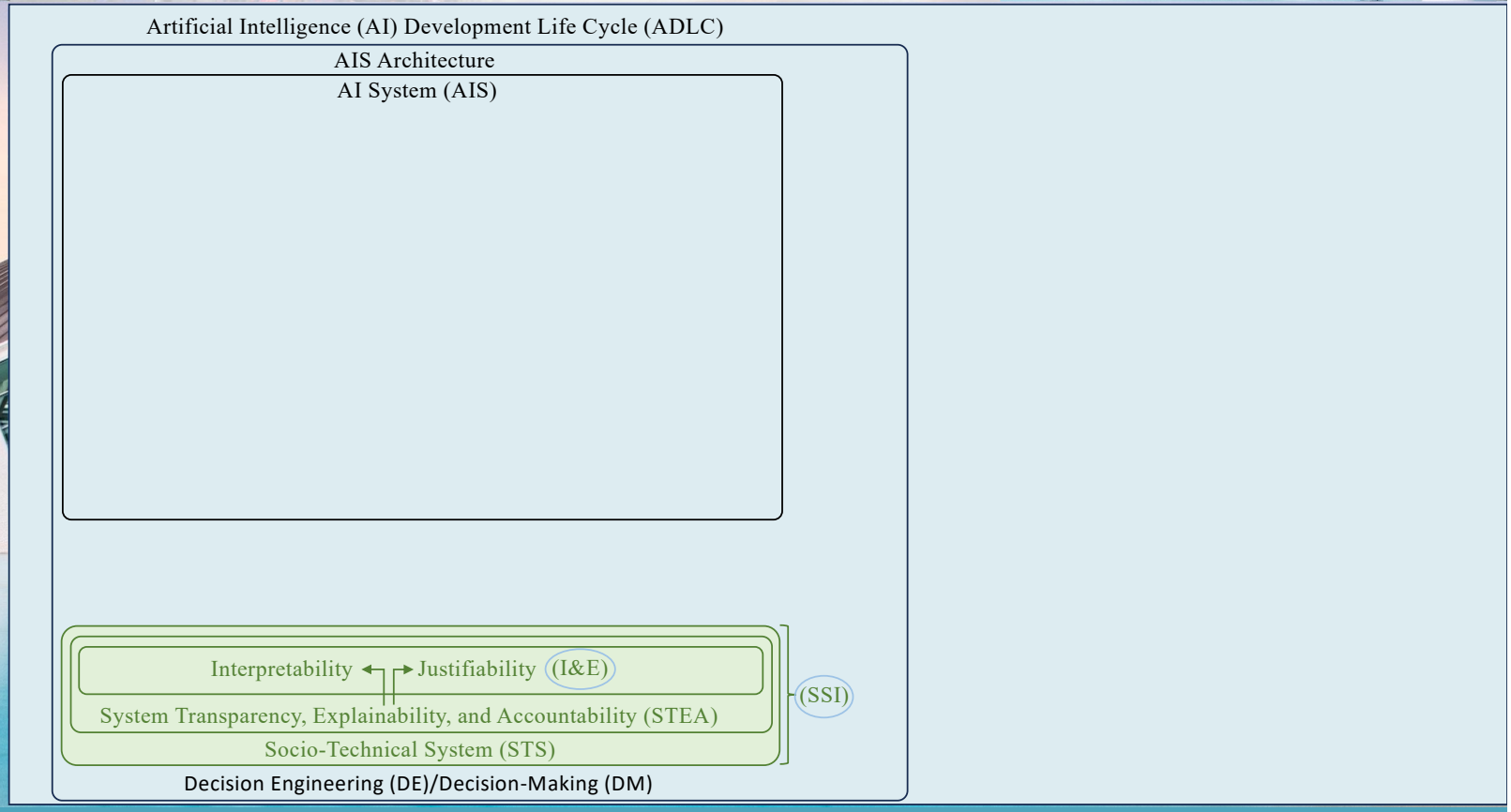
- **How fast and how cheap can I get the AIS (i.e., Conceptual Estimating)?**
- **A Prototypical AI Development Life Cycle (ADLC):**
  - (1) Planning & Collection.
  - (2) Designing & Training
  - (3) Deploying & **Optimizing**.
- **The Optimizing facet is a substantive contributor towards the success of the AIS.**
  - Without careful consideration, the **SSI** treatment for "Optimizing" can potentially derail any posited ADLC timetable for the **SSI**-centric AIS.
  - Amidst the push for **SSI**, AIS are becoming "deeper networks."
- **So, what can be done for the Optimizing facet?**
  - Perhaps, better operationalize **SSI** at the boundaries? Fugacity Phase Transition (FPT) may be useful to help identify AIS model drift.
  - Perhaps, leverage **SSI**-centric Hyper Heuristics (HH)? HH discernment may be useful since, to date, "research in the explainability of optimization techniques has largely focused on meta-heuristics" (which are solution search space-centric). There has been a dearth of research on HH methods (which focus on the search space of Lower-Level Heuristics or LLH rather than on the solutions themselves).

Experimentation




Artificial Intelligence (AI) Development Life Cycle (ADLC)
AIS Architecture
AI System (AIS)
Decision Engineering (DE)/Decision-Making (DM)

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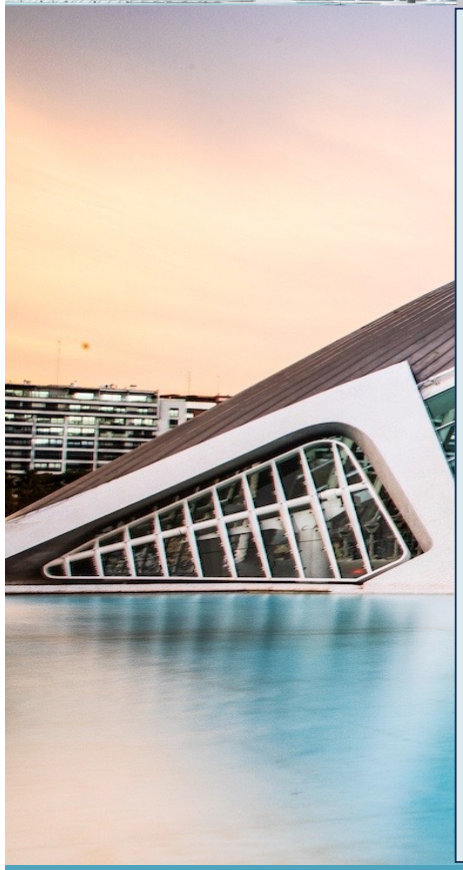
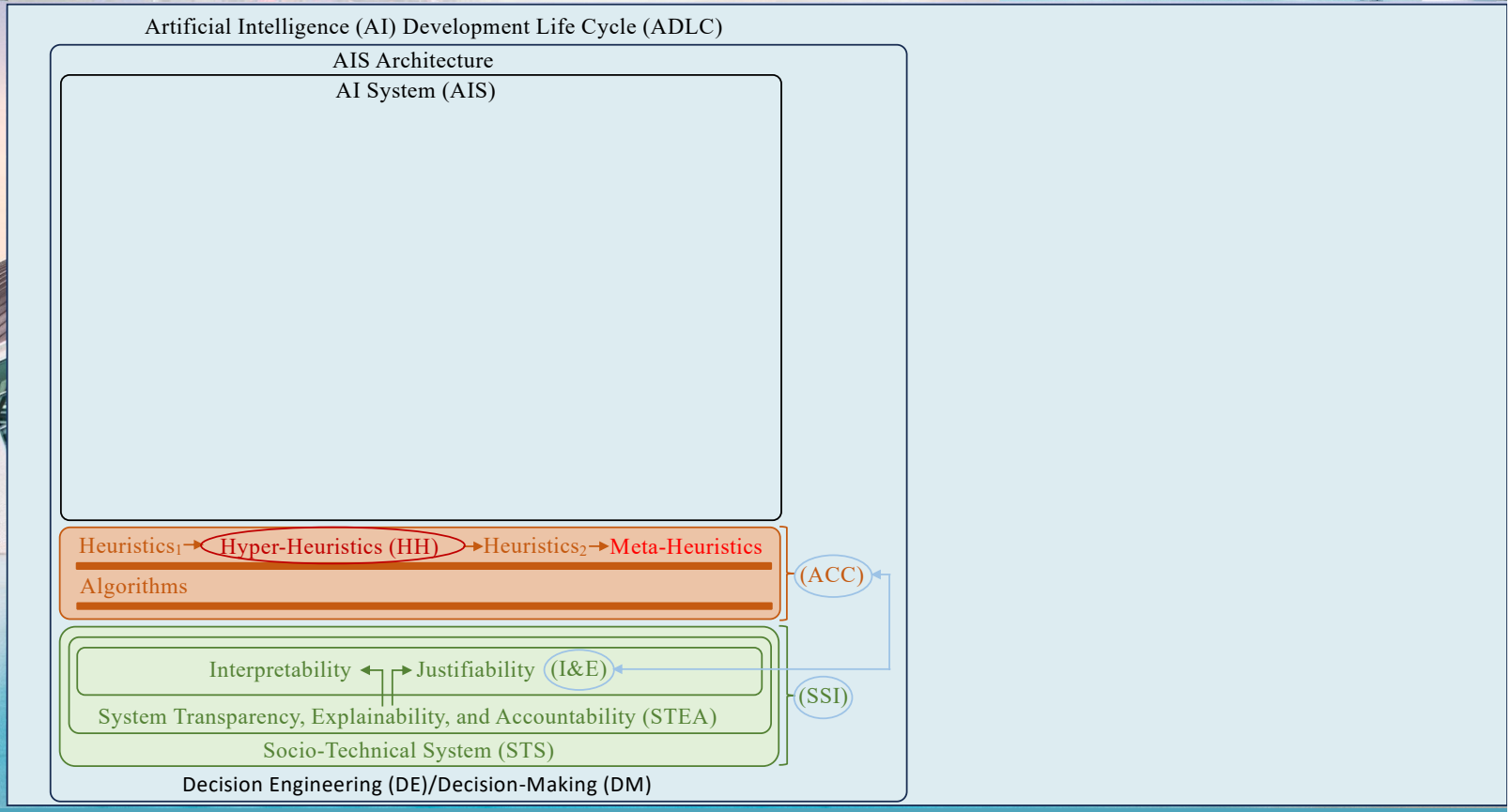
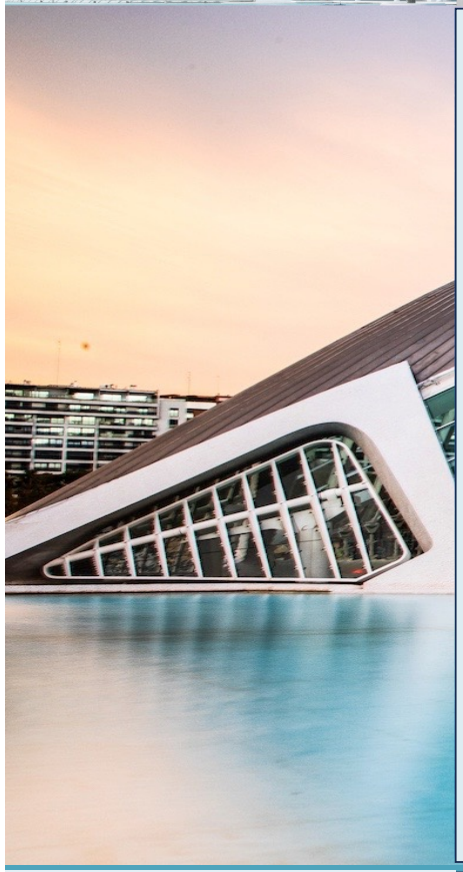
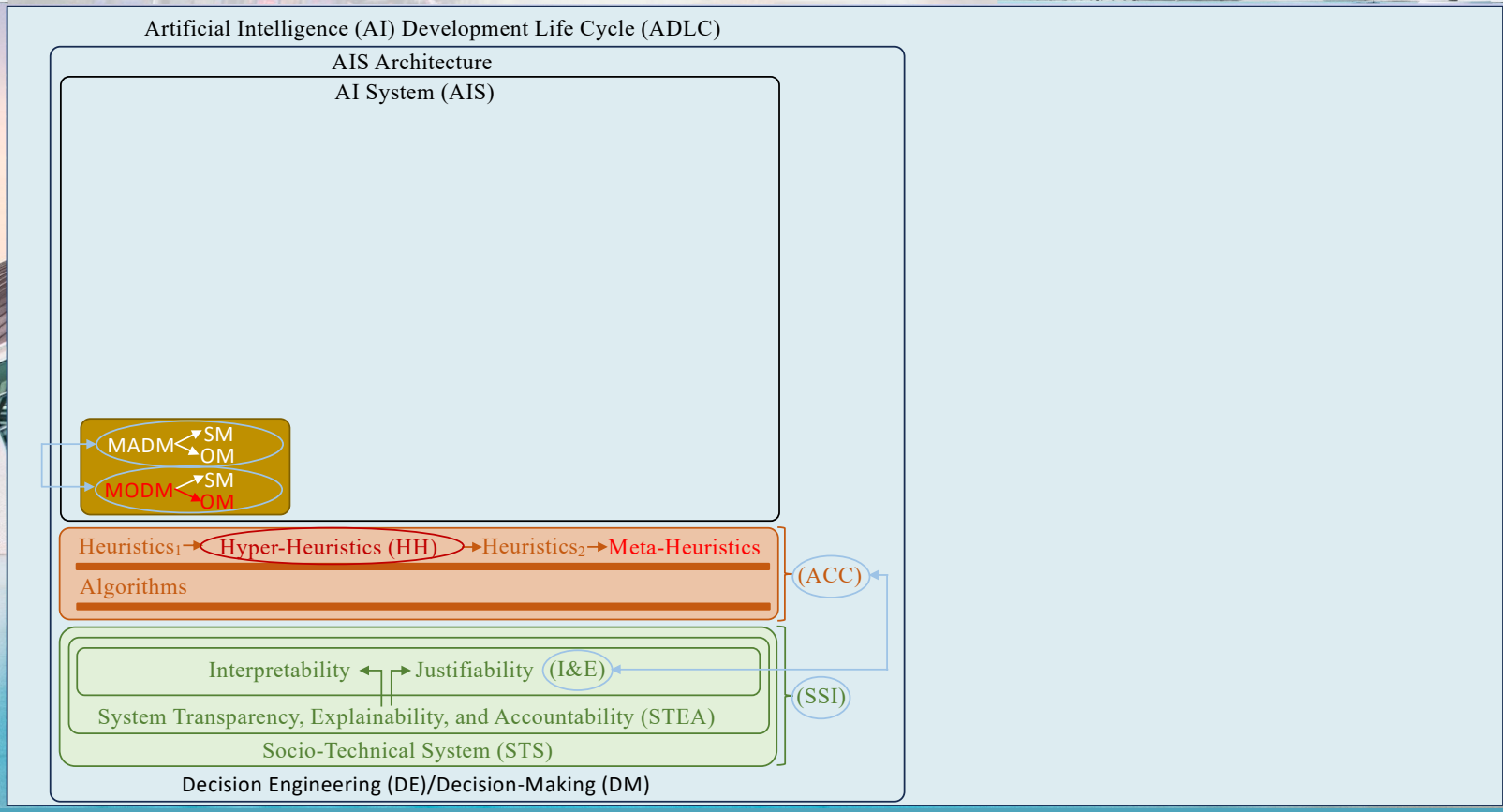
AIS Architecture
AI System (AIS)
Interpretability
Justifiability
(I&E)
System Transparency, Explainability, and Accountability (STEA)
Socio-Technical System (STS)
(SSI)
Decision Engineering (DE)/Decision-Making (DM)




Artificial Intelligence (AI) Development Life Cycle (ADLC)
AIS Architecture
AI System (AIS)
Heuristics1
Hyper-Heuristics (HH)
Heuristics2
Meta-Heuristics
Algorithms
(ACC)
Interpretability
Justifiability
(I&E)
System Transparency, Explainability, and Accountability (STEA)
(SSI)
Socio-Technical System (STS)
Decision Engineering (DE)/Decision-Making (DM)




Artificial Intelligence (AI) Development Life Cycle (ADLC)
AIS Architecture
AI System (AIS)
MADM
SM
OM
MODM
SM
OM
Heuristics1
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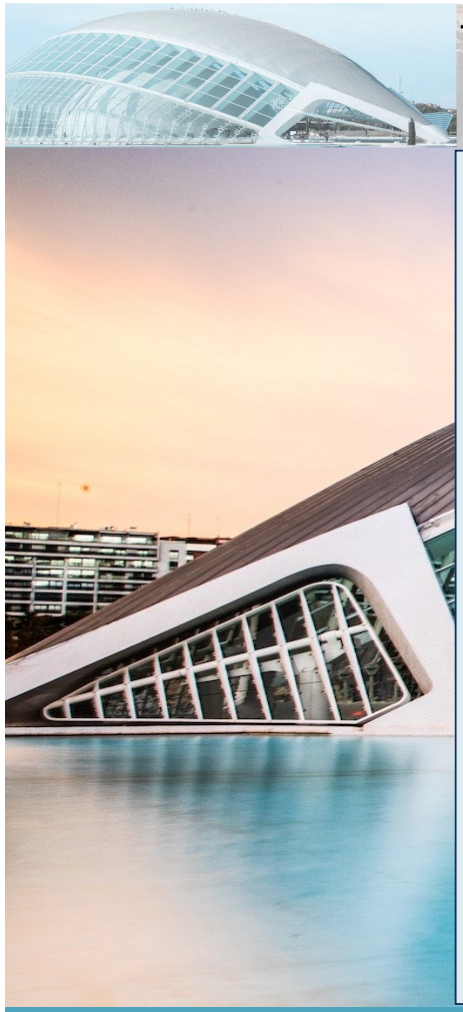

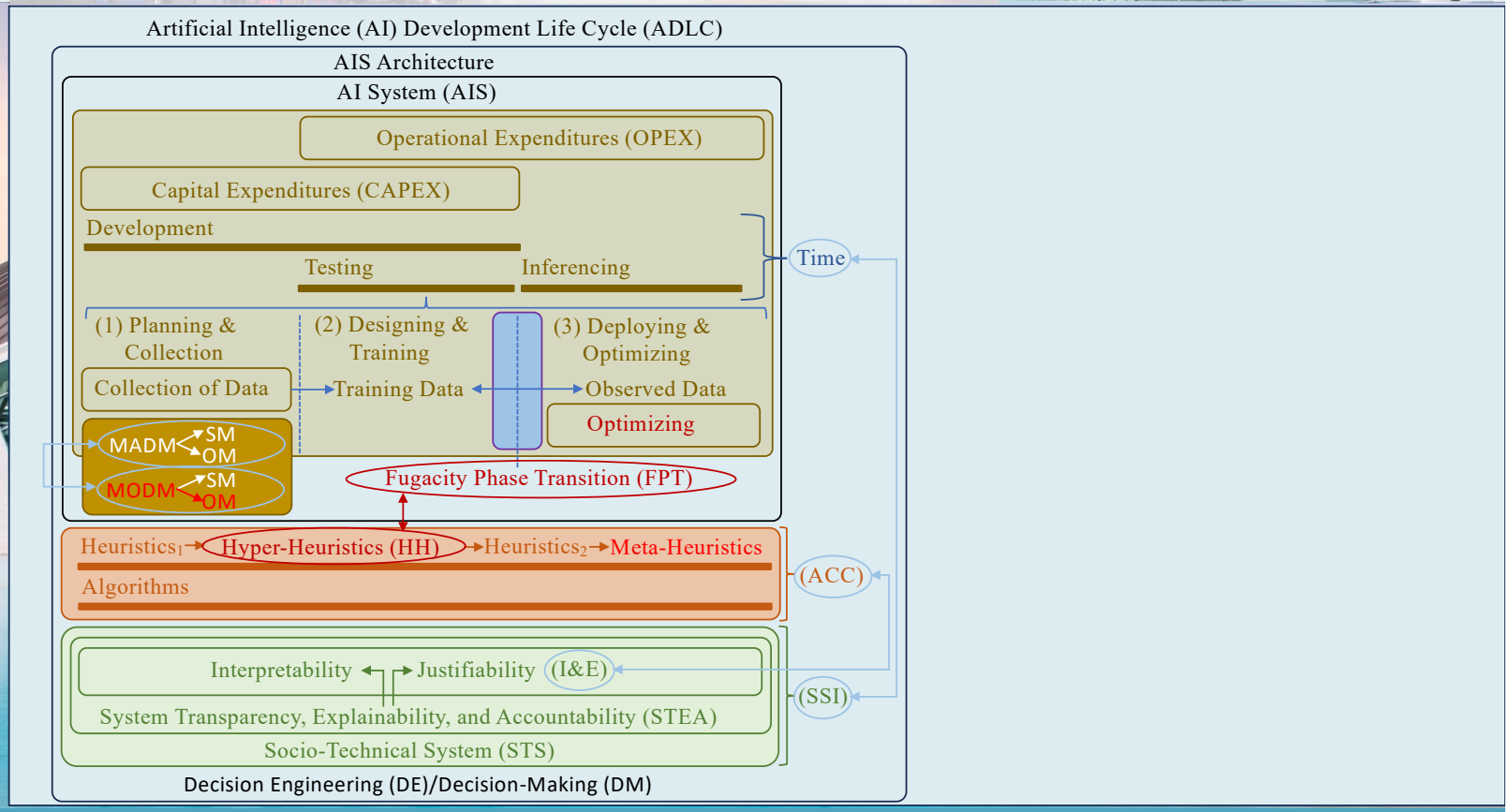
Artificial Intelligence (AI) Development Life Cycle (ADLC)
AIS Architecture
AI System (AIS)
Operational Expenditures (OPEX)
Capital Expenditures (CAPEX)
Development
Testing
Inferencing
Time
(1) Planning & Collection
(2) Designing & Training
(3) Deploying & Optimizing
Collection of Data
Training Data
Observed Data
Optimizing
MADM
SM
OM
MODM
SM
OM
Fugacity Phase Transition (FPT)
Heuristics1
Hyper-Heuristics (HH)
Heuristics2
Meta-Heuristics
Algorithms
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Interpretability
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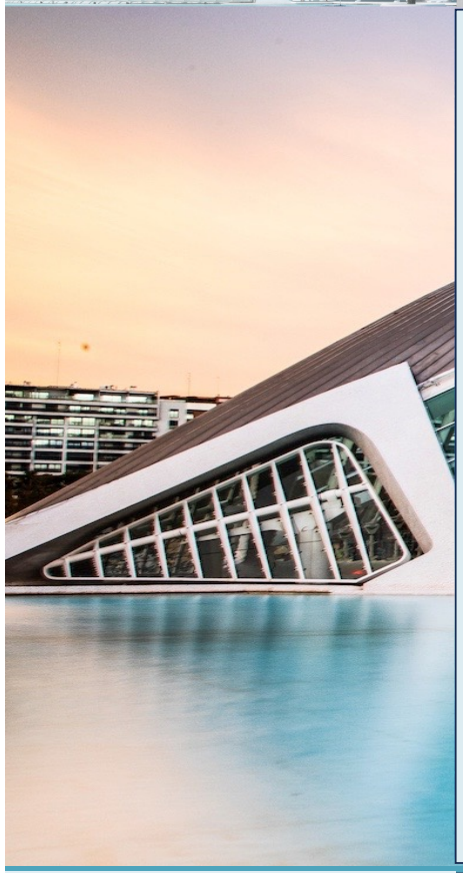
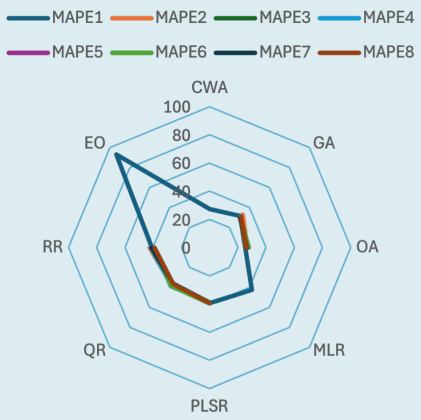
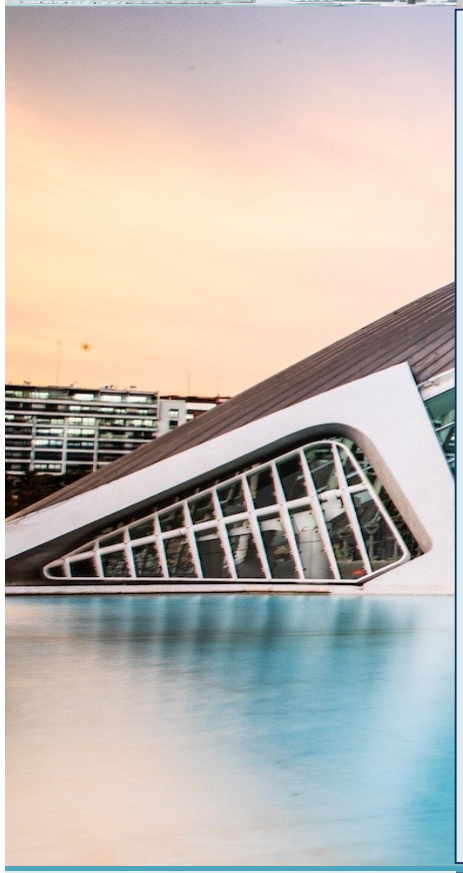


Benchmarking with Matel's Experimentation Design



- **When considering Mean Absolute Percentage Error (MAPE) :**
  - Connection Weights Algorithm (CWA)
  - Multiple Linear Regression (MLR)
  - To leverage **ML on ML**, Interpretability & Explainability (I&E) is needed.
  - Expert Opinion (EO)
  - Garson's Algorithm (GA)
  - Olden's Algorithm (OA)
  - Partial Least Squares Regression (PLSR)
  - Quantile Regression (QR)
  - Ridge Regression (RR)
- **Some findings:**
  - CWA >> MLR >>> EO; this should be no surprise, for while CWA can accommodate non-linear relationships, MLR is not able to.
  - CWA tends to outperform GA.
  - OA (as an implementation of CWA) is more nuanced than the plain vanilla CWA.
  - PLSR is better suited for multi-collinearity (i.e., when independent variables are correlated) than MLR.
  - QR can better handle outliers than MLR.

Conclusion



- **Some of the considerations when striving towards a STEA-centric AIS:**
- **HHs are becoming increasingly critical for AIS, and their SSI orientation becomes central:**
  - This paper presented an FPT/HH convergence approach, wherein low drift, narrow FPT, and high efficacy HH would be emblematic of a more SSI-centric optimization for the ADLC.
- **Given a more SSI-centric optimization for the ADLC:**
  - Conceptual estimating and cost estimator Rough Order of Magnitudes (ROMs) can indeed be made more robust (with greater discernment).
- **For the ADLC:**
  - It might be prudent to leverage STS-oriented assessments for the "Data Collection" phase.
  - It might be prudent to understand the RWS timing requirements, as this will impact the HH.
  - The various counterpoisings, such as algorithmics with heuristics and that of the MADM/MODM SM/OM are key aspects for the "Learning and Optimizing" phase.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