SIS-04 Engenharia de Sistemas (Systems Engineering)

[2025]

Prof. Dr. Christopher S. Cerqueira

Introduction

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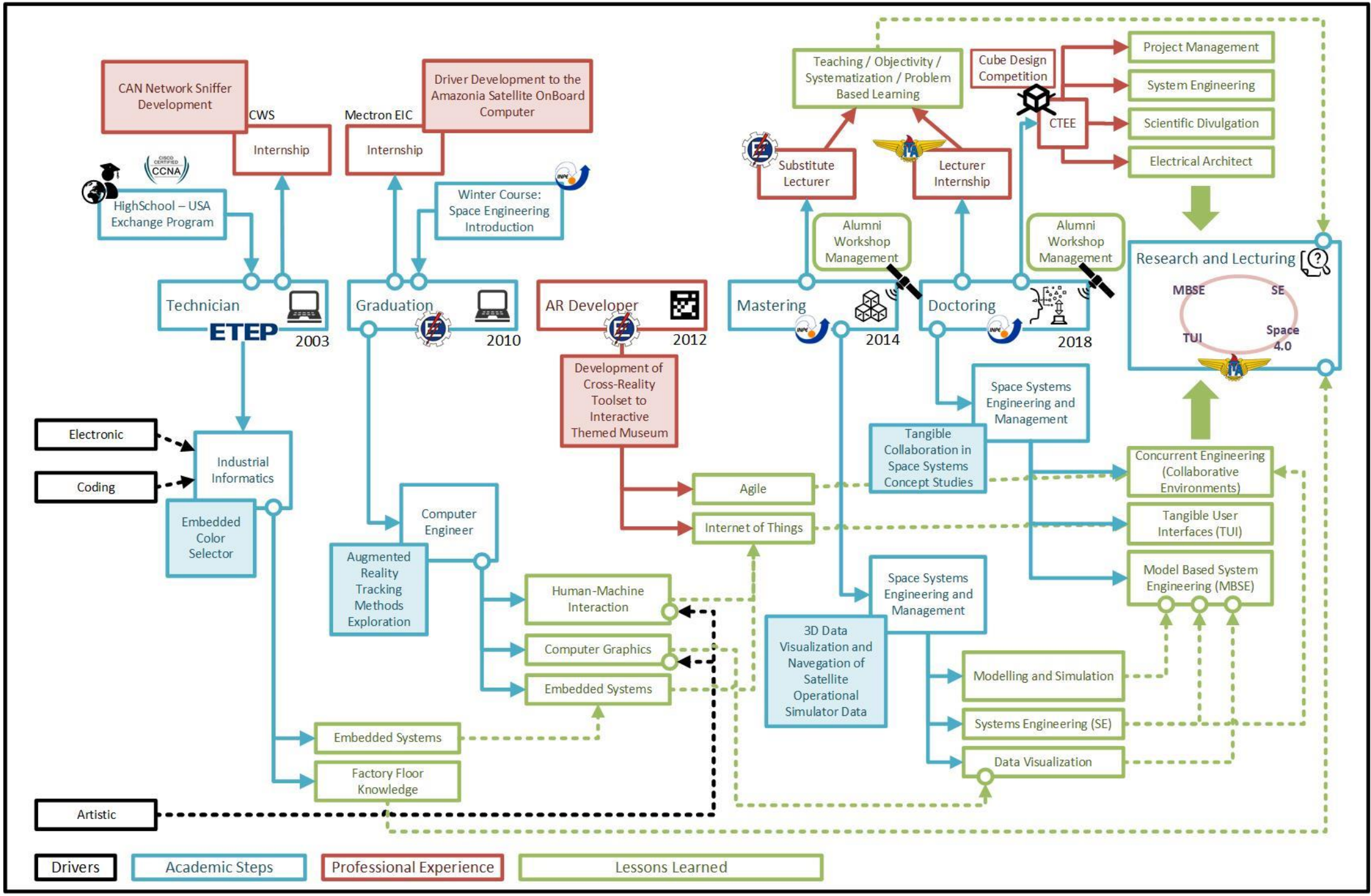
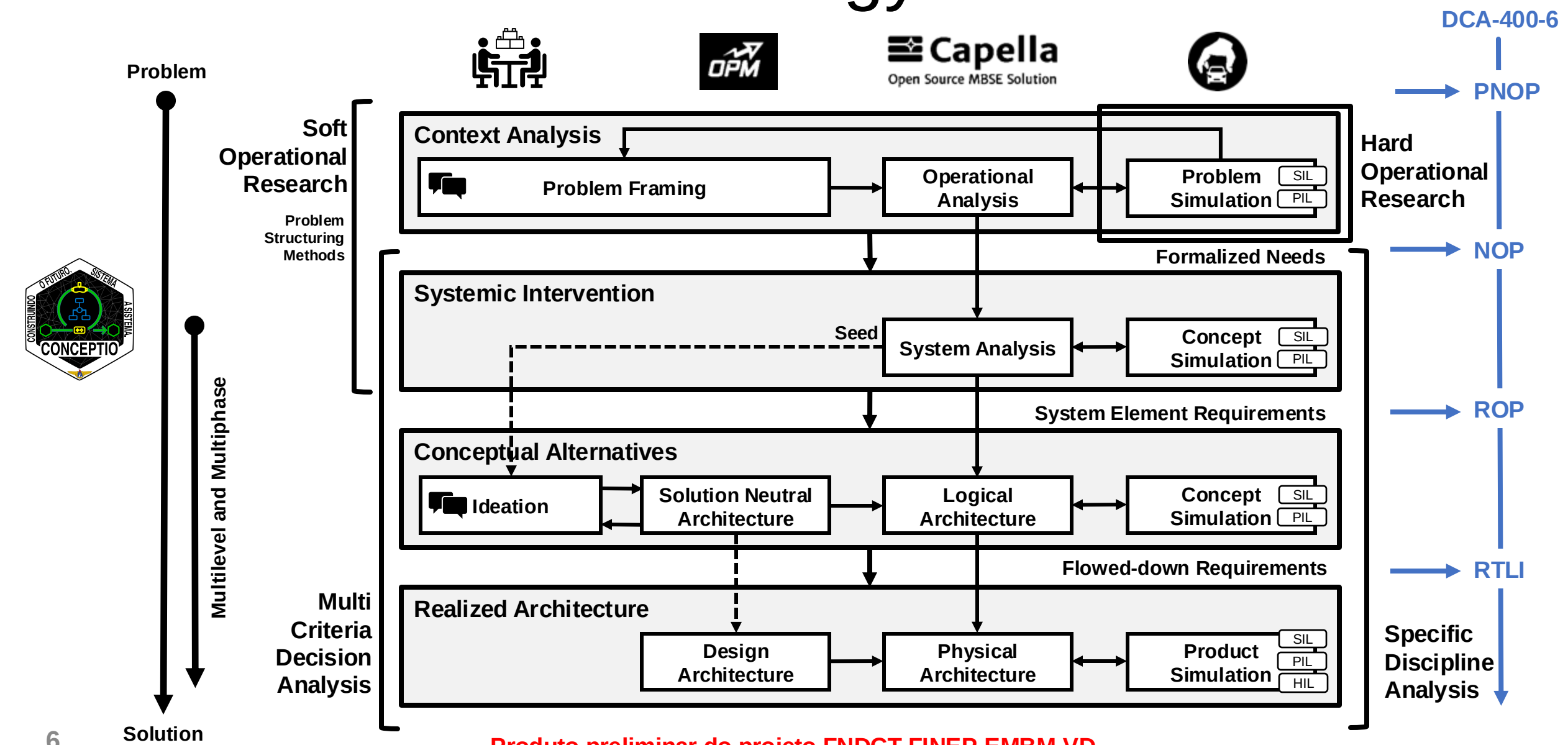
Room Ala 0 – 2011 or at CONCEPTIO LAB (1523)


CAN Network Sniffer Development
CWS
Internship
Driver Development to the Amazonia Satellite OnBoard Computer
Mectron EIC
Internship
Teaching / Objectivity / Systematization / Problem Based Learning
Cube Design Competition
Project Management
System Engineering
Scientific Divulgation
Electrical Architect
CTEE
Substitute Lecturer
Lecturer Internship
HighSchool – USA Exchange Program
Winter Course: Space Engineering Introduction
Alumni Workshop Management
Alumni Workshop Management
Research and Lecturing
MBSE
SE
TUI
Space 4.0
Technician
ETEP
2003
Graduation
2010
AR Developer
2012
Mastering
2014
Doctoring
2018
Development of Cross-Reality Toolset to Interactive Themed Museum
Space Systems Engineering and Management
Electronic
Coding
Industrial Informatics
Embedded Color Selector
Computer Engineer
Augmented Reality Tracking Methods Exploration
Agile
Internet of Things
Tangible Collaboration in Space Systems Concept Studies
Concurrent Engineering (Collaborative Environments)
Tangible User Interfaces (TUI)
Model Based System Engineering (MBSE)
Human-Machine Interaction
Computer Graphics
Embedded Systems
Space Systems Engineering and Management
3D Data Visualization and Navegation of Satellite Operational Simulator Data
Modelling and Simulation
Systems Engineering (SE)
Data Visualization
Embedded Systems
Factory Floor Knowledge
Artistic
Drivers
Academic Steps
Professional Experience
Lessons Learned

Laboratório de Pesquisa em Concepção de Sistemas Complexos

MBSE MultiMethodology Framework (3MF)



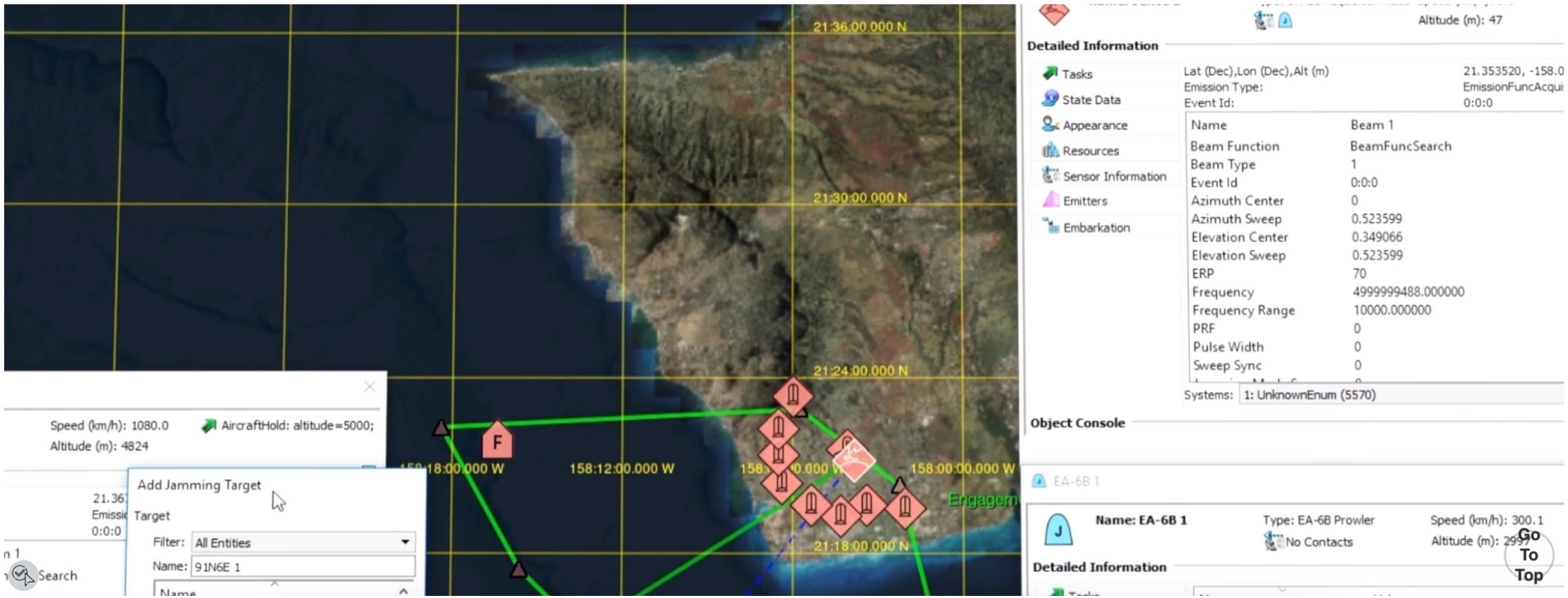
Produto preliminar do projeto FNDCT-FINEP-EMBM-VD

VR-Forces

The MAK ONE Multi-Domain Computer Generated Forces

Fill your synthetic environment with urban, battlefield, maritime, air, and space activity using this powerful and flexible computer-generated forces platform.

VR-Forces simulates the full range of domains that coexist as the whole earth - from the ocean floor to the elliptical orbits around our planet. Simulate your entities, their relationships to one another, the terrains they live on, the localized weather systems and the environmental effectors to meet your simulation needs.



https://www.mak.com/mak-one/apps/vr-forces

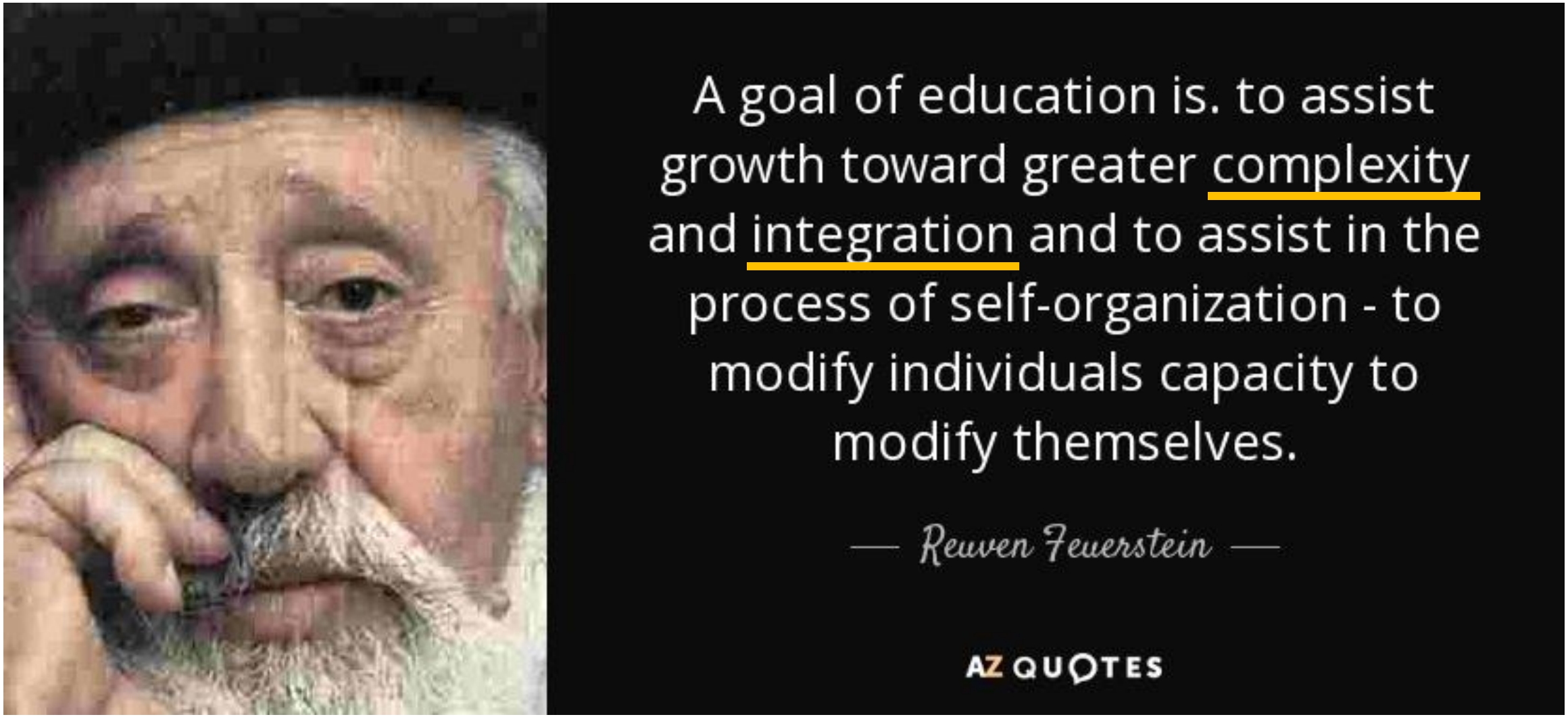
Technical Support to FAB Projects

Air Domain Study (ADS)
- *SIMUA*
- *VD*

Custom Projects

Model based Mission Engineering

MultiDomain Demonstration and Research Arena (System of Systems)



#escolasempartido

Rules

3 DEVERES E DIREITOS DOS ALUNOS

3.1 DEVERES

São deveres dos alunos de graduação:

a) comparecer, pontualmente, a todas as atividades escolares;

b) apresentar, com pontualidade, todos os trabalhos escolares exigidos;

c) dedicar-se exclusivamente às atividades escolares prescritas nesta Norma, salvo outras que venham a ser especificamente autorizadas pela autoridade competente;

d) observar rigorosa probidade na execução dos trabalhos escolares;

e) obedecer a todas as regras, normas, prescrições, instruções e ordens emanadas de autoridade competente; e

f) apresentar-se sempre de maneira digna e correta, quer no Instituto, quer fora dele, de modo a manter elevado o conceito do ITA e da Aeronáutica.

3.2 DIREITOS

Ao aluno do Curso de Graduação do ITA é assegurado:

c) a revisão de prova, desde que solicitada no prazo estabelecido em instrução própria, por escrito e devidamente fundamentada, à autoridade competente;

i) recorrer de punição, por escrito, à autoridade do ITA que a aplicou e em última instância ao Reitor do ITA;

Who are you?

Motivation


Quito
Manaus
Belém
São Luís
Fortaleza
Natal
Teresina
Recife
Porto Velho
Rio Branco
Lima
Salvador
Brasília
Cuiabá
Goiânia
Belo Horizonte
Vitória
Santa Cruz de la Sierra
Campo Grande
São Paulo
Rio de Janeiro
Curitiba
Asunción
Florianópolis
Córdoba
Porto Alegre

Case – Same as PRJ - Passenger Transport Aircraft (Regional / Commuter)

- 90 passengers in 1 class
- Range of 3,700km
- Runway length take-of: 1,800m
- Runway length landing: 1,150m
- Mach cruising: between 0.75 and 0.80
- Reservations: 45min loiter + cruise for 200 nautical mile alternative

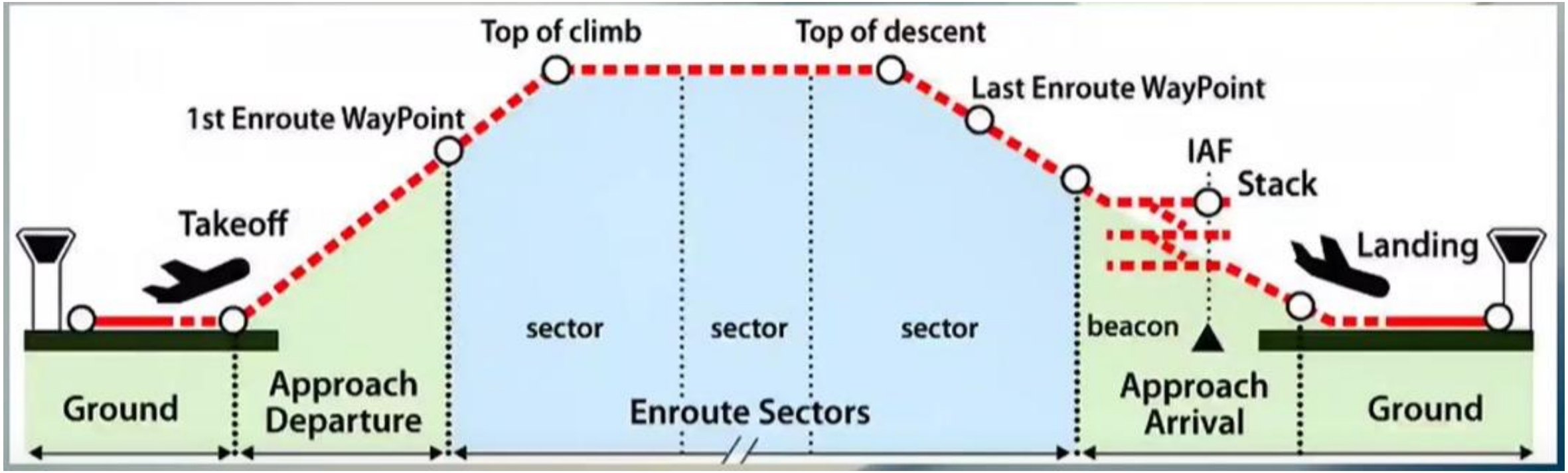
Case


90-SEAT
SYSTEMS ENGINEERING
90-SEAT
N ENGINEERING
SYSTEMS ENGINEERING

but... the aircraft performance itself it is the least of our problems...

- the aircraft must be piloted.. (by humans? by one person?)
- what about the airline? airport? luggage? tickets? (how many procedures do it interfaces with the aircraft?)
- what about the air traffic management? (do we have the right to have the fair route?)
- how about the people inside? meals? drinkings? bedding?
- weather? (is it safe to fly?)
- how is going to be the ground maintenance?

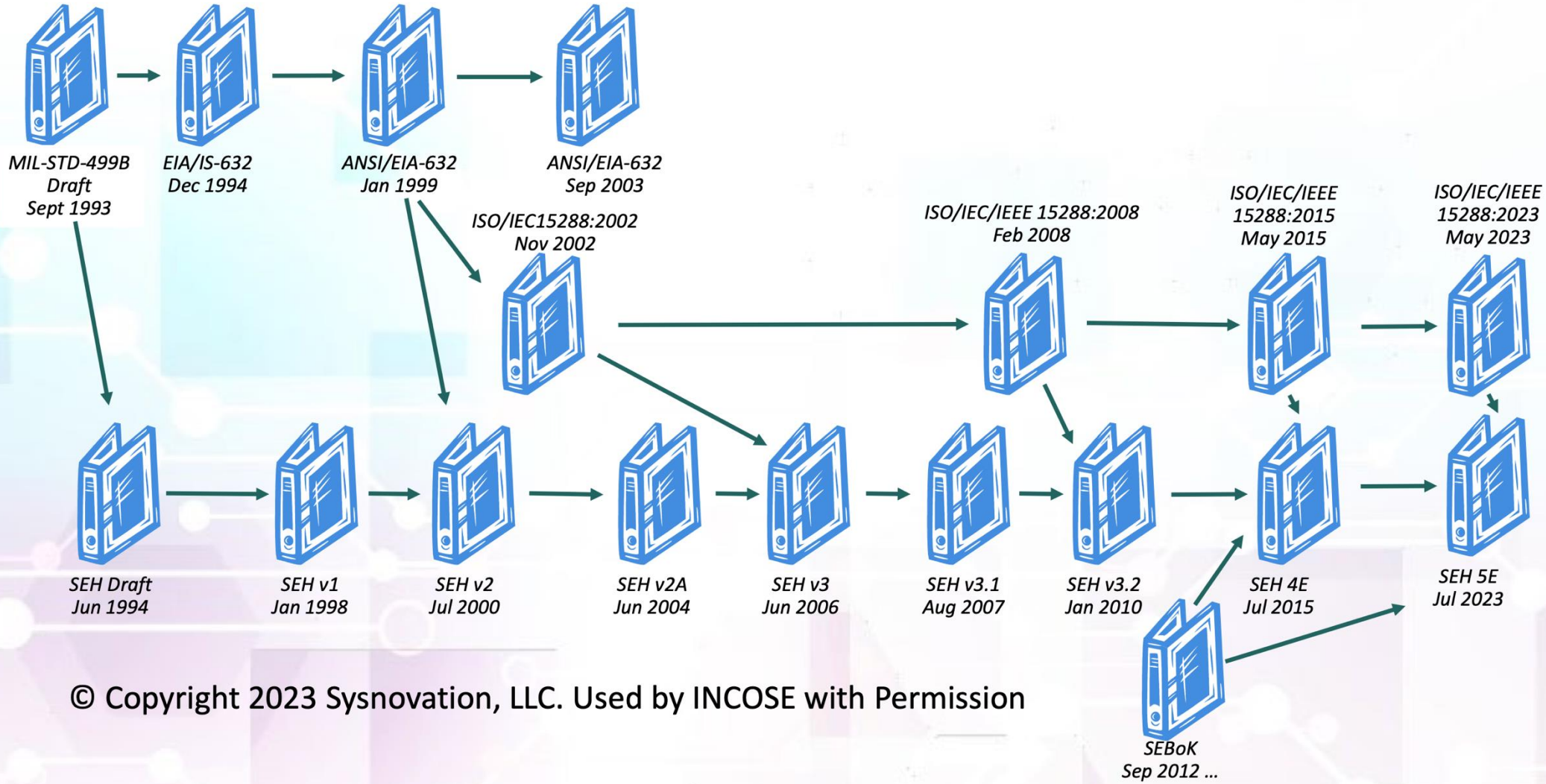
Typical Operation



INCOSE

INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

INCOSE Systems Engineering Handbook (SEH) History



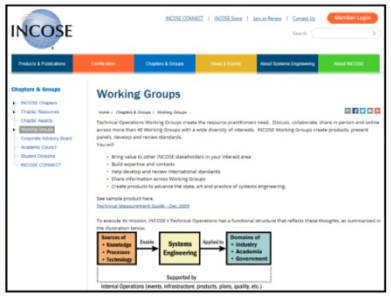
Three Main SEH Inputs

ISO/IEC/IEEE 15288 standard

- Developed by the consensus of SE experts from government, industry, and academia
- Defines a set of processes and associated terminology

INCOSE Working Groups

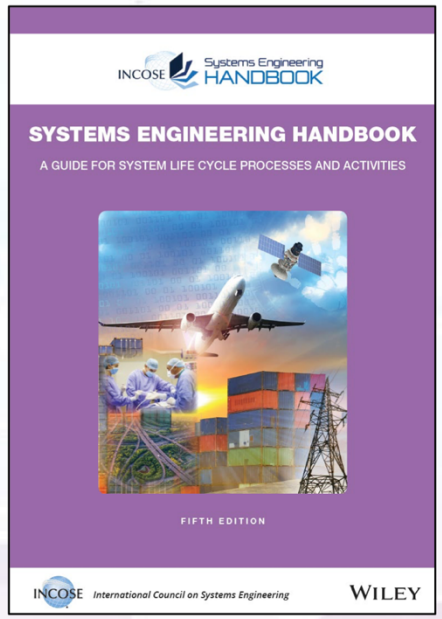
- Subject Matter Experts from the INCOSE technical community serve as section authors
- Handbook includes summaries and pointers to INCOSE Working Group products



SE Body of Knowledge (SEBoK)

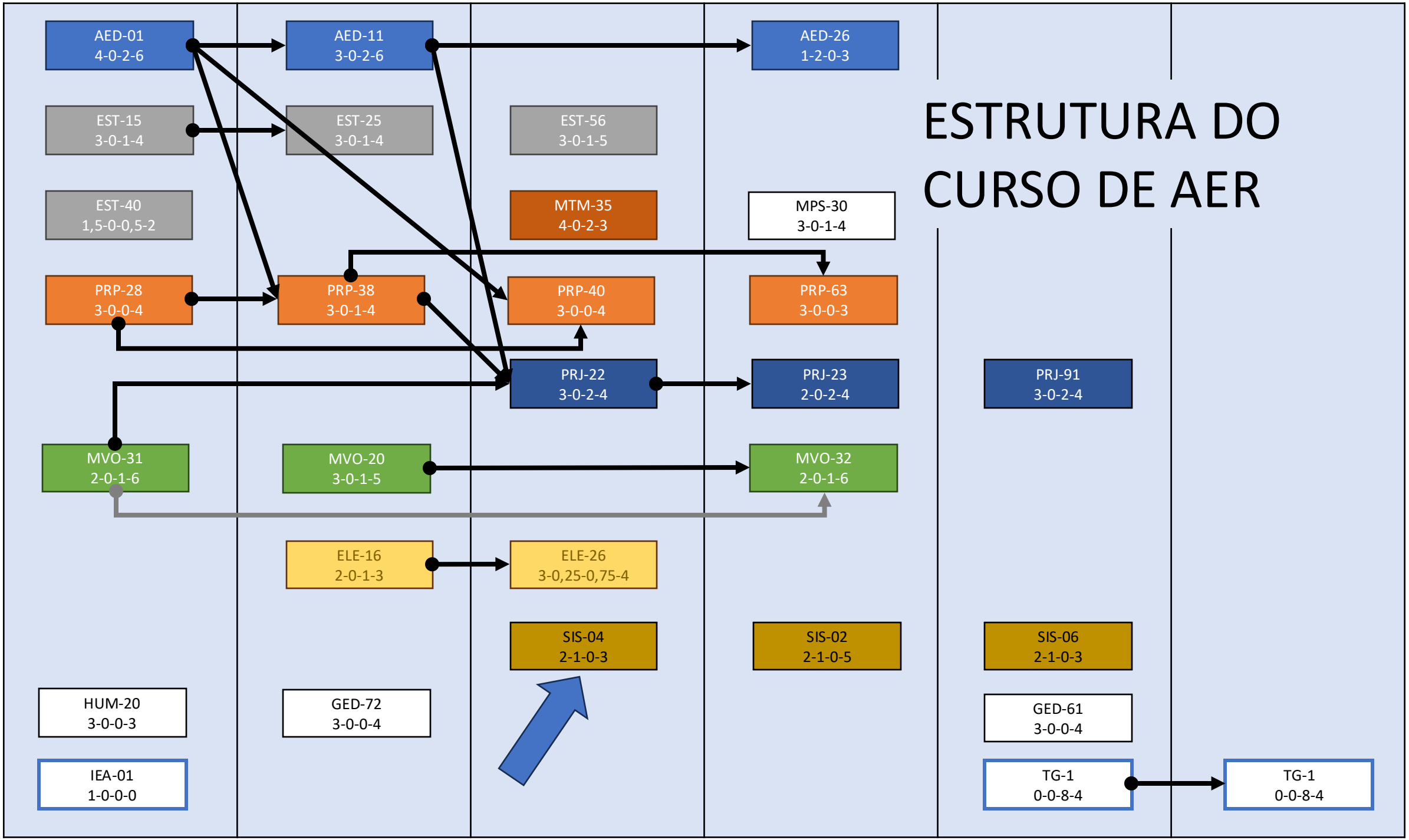
- Reflects the state-of-the-knowledge of Systems Engineering
- Provides a widely accepted, community-based, and regularly updated wiki-based baseline of SE knowledge

SEBoK
GUIDE TO THE SYSTEMS ENGINEERING BODY OF KNOWLEDGE



Course layout

ESTRUTURA DO CURSO DE AER



Discplinas do Curso de AER

SIS-04 – Engenharia de Sistemas. (Hoje)

- Horas semanais: 2-0-1-3. Pré-requisitos: Não há.
- Conceitos básicos: sistema, engenharia de sistemas, requisitos, funções, contexto, estrutura, comportamento. Arquitetura de sistemas: arquitetura funcional e arquitetura física. Noções de modelagem. Organização de projetos. O processo de engenharia de sistemas: análise de missão, análise das partes interessadas, engenharia de requisitos, análise funcional, análise de perigos, projeto de arquitetura, projeto detalhado. Noções de verificação e validação. Noções de controle de configuração.
- Bibliografia: EUROPEAN SPACE AGENCY. European cooperation on space standardization. Noordvijk: ECSS Pub: ESA Publications Division, 1996. LARSSON, W. et al. Applied space systems engineering. New York: McGrawHill, 2009. NASA. Systems engineering handbook. Houston: NASA, 1996. (SP6105).

Proposta

Migrando gradativamente:

- ~~**SIS-04**~~ **PRJ-XX Engenharia de Sistemas.**

Requisito: Não há. Horas semanais: 2-0-1-3.

- Processo de desenvolvimento de aeronaves; papel dos usuários, operadores e manutentores; estruturação do conceito de operação, manutenção e suporte; captura de requisitos; desenvolvimento de arquiteturas de aeronaves; avaliação de segurança; processos de verificação, validação e certificação; conceitos da engenharia de sistemas e do desenvolvimento integrado de produto; utilização de abordagens baseadas em modelos.

Bibliografia:

- **Beland, S., Guidelines for Development of Civil Aircraft and Systems – ARP4754B, SAE International, 2023,**
- Walden, D. D., Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, 5a ed., NJ, Wiley, ISBN: 978-1-119-81429-0, 2023,
- De Florio, F., Airworthiness: An introduction to aircraft certification and operations. 3a ed, Butterworth-Heinemann, ISBN: 978-0-08-100888-1, 2016

References

- **INCOSE. INCOSE Systems Engineering Handbook. John Wiley & Sons, 2023.**
- Kossiakoff, Alexander, Steven M. Biemer, Samuel J. Seymour, and David A. Flanigan. Systems Engineering Principles and Practice. John Wiley & Sons, 2020.
- Voirin, Jean-Luc. Model-Based System and Architecture Engineering with the Arcadia Method. Elsevier, 2017.

Other References

- **SAE, Guidelines for Development of Civil Aircraft and Systems ARP4754B - https://www.sae.org/standards/content/arp4754b/**
- SAE, Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment ARP4761A - https://www.sae.org/standards/content/arp4761a/
- ANAC, RBAC - Regulamentos Brasileiros da Aviação Civil - https://www.anac.gov.br/assuntos/legislacao/legislacao-1/rbha-e-rbac/rbac
- DECEA, Concepção Operacional ATM Nacional - https://publicacoes.decea.mil.br/publicacao/DCA-351-2
- **De Florio, F., Airworthiness: An introduction to aircraft certification and operations. 3a ed, Butterworth-Heinemann, ISBN: 978-0-08-100888-1, 2016**

Fevereiro

	S	T	Q	Q	S	S	D
						1	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
1	24	25	26	27	28		

Março

	S	T	Q	Q	S	S	D
1						1	2
2	**3**	**4**	**5**	6	7	8	9
3	10	11	12	13	14	15	16
4	17	18	**19**	20	21	22	23
5	**24**	**25**	26	27	28	29	30
6	31						

Abril

	S	T	Q	Q	S	S	D
6		1	2	3	4	5	6
7	7	8	9	10	11	12	13
8	14	15	16	17	**18**	☹	**20**
s	**21**	22	23	24	25	26	27
1	28	29	30				

Maio

	S	T	Q	Q	S	S	D
1				**1**	**2**	☹	4
2	5	6	7	8	9	10	11
3	12	13	14	15	16	17	18
4	19	20	21	22	23	24	25
5	26	27	28	29	30	31	

Junho

	S	T	Q	Q	S	S	D
5							1
6	2	3	4	5	6	7	8
7	9	10	11	12	13	14	15
8	16	17	18	**19**	20	☹	22
Ex1	23	24	25	26	27	28	29
Ex2	30						

Julho

	S	T	Q	Q	S	S	D
Ex2		1	2	3	4	5	6
	7	8	**9**	10	11	12	13
	14	15	16	17	18	19	**20**
	21	22	23	24	25	26	**27**
1	28	29	30	31			

			Theory		Hands-on	
	Week	Teory	Individual	W	Group exercises	W
Learning the Theory	1	Syllabus Introduction	Systems Engineer Mindset reading (10 questions)	5%		0%
	24-Feb	System Thinking				
	28-Feb	ARP4754 Introduction				
	2	Stakeholders	Stakeholder and Metrics Reading (10 questions)	5%	Create a network from a problem following the paper instructions (4 stks)	10%
	03-Mar	Mesures of Success				
	07-Mar	**Arcadia-Capella Introduction**				
	3	Life Cycle	Definition Readings (10 questions)	5%	Create a CONOPSs with 4 scenarios.	10%
	10-Mar	CONOPs				
	14-Mar	4.1 Conceptual Aircraft/System Development				
	4	Functions	Definition Readings (10 questions)	5%		0%
	17-Mar	Functional Architecture				
	21-Mar	**Functional Diagram / eFFBD**				
	5	**Block Diagram**	Definition Readings (10 questions)	5%	Create a functional architecture from the CONOPs (15fnc / 3 layers)	10%
	24-Mar	**Interfaces / N2**				
	28-Mar	4.2 Aircraft Function Development				
	6	**Statemachine Diagram**	Definition Readings (10 questions)	5%	Exercises to create statemachines (4 systems)	10%
	31-Mar					
	04-Apr	4.3 Allocation of Aircraft Function to Systems				
	7	**Sequence Diagram**	Definition Readings (10 questions)	5%	Exercise to create event sequence from the CONOPS scenarios	10%
	07-Apr					
	11-Apr	4.4 Development of System Architecture				
	8	P1	Selection of 15 questions and apply into a context.	65%	One exercise with all steps.	50%
	14-Apr					
	18-Apr					
				100%		**100%**

		Theory		Hands-on	
	Week	Teory	Individual	W	Group Exercises	W
Hands-on Activities	**9**	Functional Hazard Analysis	Definition Readings (10 questions)	15%	AG-09 - Hazard Analyzis of the functions.	10%
	28-Apr	**Class Diagram**				
	02-May	5.3 Requirement Capture / 4.5 Allocation of Sys Req				
	10	Requirements	Definition Readings (10 questions)	15%	AG-10 - Write 30 requirements in 3 levels (User/Sys/SubS) w/ verification methods/success	10%
	05-May	Verification and Validation (Certification)				
	09-May	5.4 Requirements Valid / 5.5 Implement Verif				
	11	**Operational Analysis**			AG-11 - Prepare a blackbox system	10%
	12-May					
	16-May	5.1 Safety Assessment				
	12	**System Analysis**			AG-12 - Escrever os requisitos do nível de sistema e gerar o documento de requisitos.	10%
	19-May					
	23-May					
	13	**Logical Architecture**			AG-13 - Preparar a decomposição funcional e requisitos de subsistemas	30%
	26-May					
	30-May	4.6 System Implementation				
	14	**Physical Architecture**			AG-14 - Preparar a solucão a ser construída, explicando como vai ser instrumento.	0%
	02-Jun	Visita ao Laboratório e Encerramento do Curso e discussão sobre P2				
	06-Jun					
	15	Design Presentation			AG-15 -	50%
	09-Jun					
	13-Jun					
	16	P2	Full process application on Capella	70%	AG-16 -	0%
	16-Jun					
	20-Jun					
				100%		**120%**
	EXAM	**Grupo: Write a journal paper (min 10pgs / max 15pgs) w/ Recorded Presentation (20min), use the template of the SIGE event.**				**100%**
	23-Jun					
	04-Jul					

Grading

B1 - IND (40%)	AI-01	AI-02	AI-03	AI-04	AI-05	AI-06	AI-07	AI-08(P1)	
	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	65,0%	**100%**
	0,5%	*0,5%*	*0,5%*	*0,5%*	*0,5%*	*0,5%*	*0,5%*	*6,5%*	*10%*
B1 - HON (60%)	AG-01	AG-02	AG-03	AG-04	AG-05	AG-06	AG-07	AG-08(P1)	
	0,0%	10,0%	10,0%	0,0%	10,0%	10,0%	10,0%	50,0%	**100%**
	0,0%	*1,5%*	*1,5%*	*0,0%*	*1,5%*	*1,5%*	*1,5%*	*7,5%*	*15%*
							Total no semetre:		**25%**

B2 - IND (40%)	AI-09	AI-10	AI-11	AI-12	AI-13	AI-14	AI-15	AI-16 (P2)	
	15,0%	15,0%	0,0%	0,0%	0,0%	0,0%	0,0%	70,0%	**100%**
	1,5%	*1,5%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*7,0%*	*10%*
B2 - HON (60%)	AG-09	AG-10	AG-11	AG-12	AG-13	AG-14	AG-15	AG-16 (P2)	
	10,0%	10,0%	10,0%	10,0%	30,0%	0,0%	50,0%	0,0%	**120%**
	1,5%	*1,5%*	*1,5%*	*1,5%*	*4,5%*	*0,0%*	*7,5%*	*0,0%*	*18%*
							Total no semetre:		**28%**
Exame (100%)	100%								
	50%							Total no Ano:	**103%**

First Final Considerations

Expert System Engineering Architecture...
Boeing · São José dos Campos, São Paulo, Brasil

Aplicar | Salvar | ...

Preferred Qualifications (Education/Experience):

- System engineering work experience (desirably in HVAC, or ECS, or automotive cooling/heating systems);
- Experience in Model based design or Model based system engineering.
- Experience in traditional engineering analytical methods and Aerospace/Industry Standards (SAE ARP 4754A, SAE ARP 4761, RTCA DO-160, RTCA DO-178, RTCA DO-331, etc).
- Master's Degree, or PhD or equivalent degree in engineering, computer science, mathematics, physics, or chemistry;
- System engineering work experience, including supplier selection and product development;
- Requirements configuration management tools (DOORS).
- Experience with one or more of the following programming tools (Cameo® – SysML, MBSE-Capella®, Matlab® – Simulink® and/or Simscape® Toolboxes, FloMaster®, AMESim®, Python® etc.)

Relocation:

ENGENHEIRO(A) DESENVOLVIMENTO D...
Embraer · São José dos Campos, São Paulo, Bra...

Aplicar | Salvar | ...

Como Será o Seu Dia a Dia

Como integrante do time as responsabilidades e atribuições são de:

- Captura e desdobramento de requisitos com o uso de ferramentas de modelagem e simulação;
- Modelagem e simulação de sistemas aeronáuticos de comandos de voo, piloto automático e navegação e lógicas de controle desses sistemas;
- Testes e avaliações das lógicas propostas em ambiente de simulador com piloto no loop;
- Análise de problemas gerais e proposta de soluções e modificações ao produto.

Requirements And Qualifications

Para este desafio, você precisa ter:

- Superior completo em Engenharia Elétrica, Eletrônica e/ou Controle e Automação com CREA ativo ou ter as documentações necessárias para obter;
- Inglês avançado para leitura, escrita e conversação;
- Experiência prévia em modelagem e simulação usando Matlab/Simulink e/ou outra ferramenta de modelagem ou programação.

FINAL CONSIDERATIONS

- This course is always being **“readjusted”**
- **Problems** are expected.
  - *We are going to work hard to solve them*.
- *Expecting **feedbacks and lessons learned**.*
- ***We need*** to be **patience** in this endeavor.
  - Hope you have fun learning through the course.