

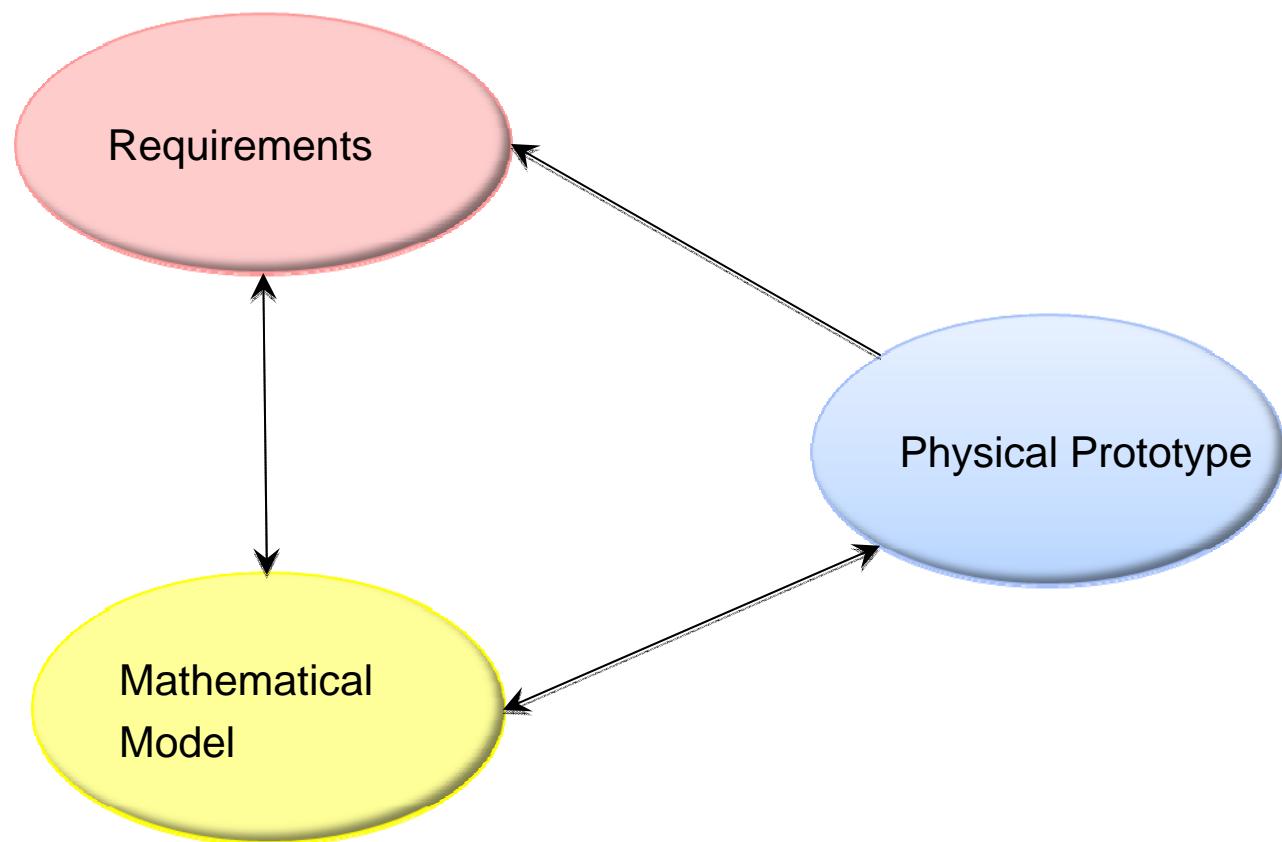
Concept Realisation Laboratory

FluMeS and Machine Design



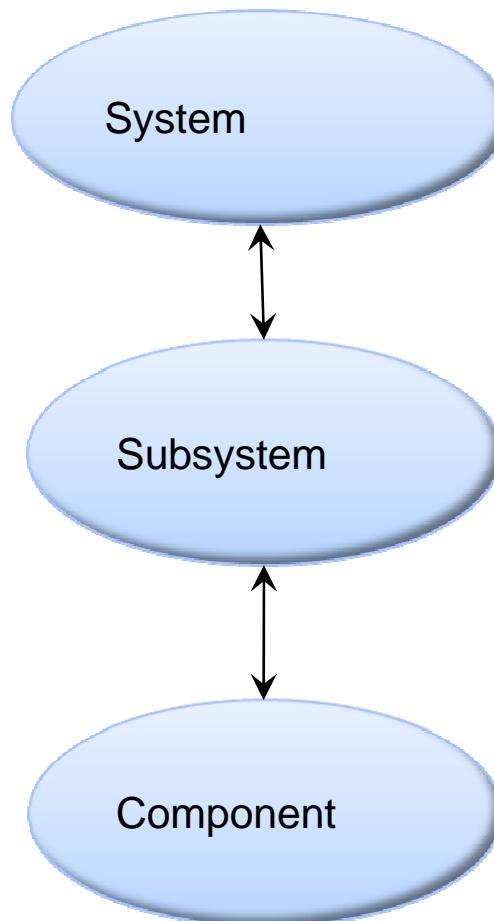
Petter Krus **IEI/FluMeS**

Machine Design/Flumes Research philosophy



Machine Design/Flumes

Vertical Integration



Increased Intelligence in Products

- New products tend to have more intelligence than before. This applies to a wide range of products. This is particularly true for the CRL application areas:
 - Cars
 - Aircraft
 - Construction Machinery
 - Industrial Manufacturing Systems



Technologies

- These kind of systems are characterized by a close coupling between:
 - Mechanical system
 - Power transmission/Actuation systemSensors
 - Control System
- *This requires multi domain co-design.*

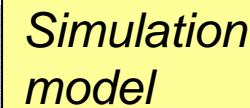
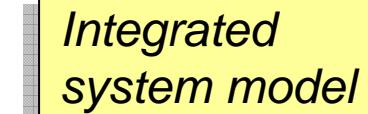
Strong Trend Towards Multi Domain Analysis and Optimization

The screenshot shows a Microsoft Excel spreadsheet titled "Flight Route Planning.xlsx". The data is organized into several tables:

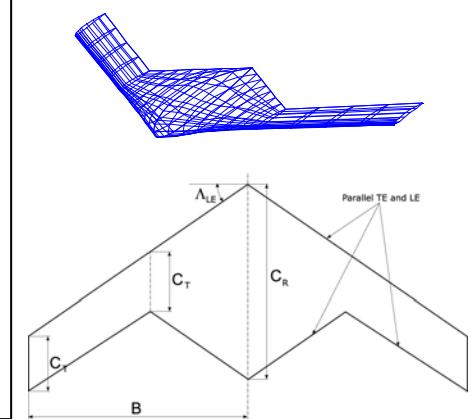
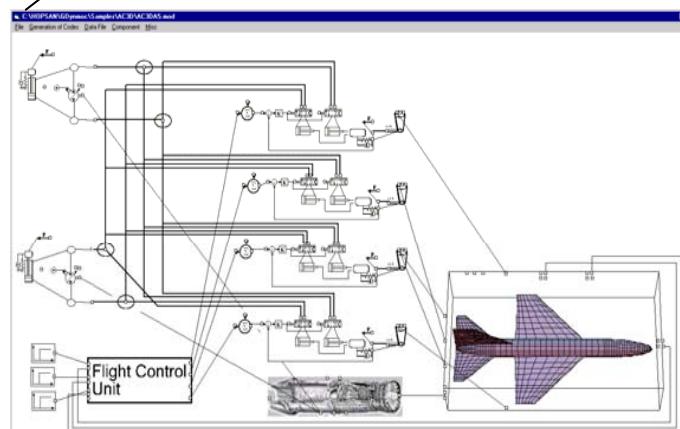
- Flight Routes:** Columns A through Z show routes from cities like Paris, Berlin, and London to cities like Rome, Madrid, and Barcelona. Each row includes columns for city names, distances, speeds, and arrival times.
- Systems:** A table in the bottom-left corner lists system characteristics such as Range, Accuracy, and Speed.
- Cost:** A summary table at the bottom provides a cost analysis for different flight routes.

A chart on the right side of the screen displays a map of Europe with flight routes plotted as red lines between various cities.

Spread sheet with
design analysis and
optimization tools

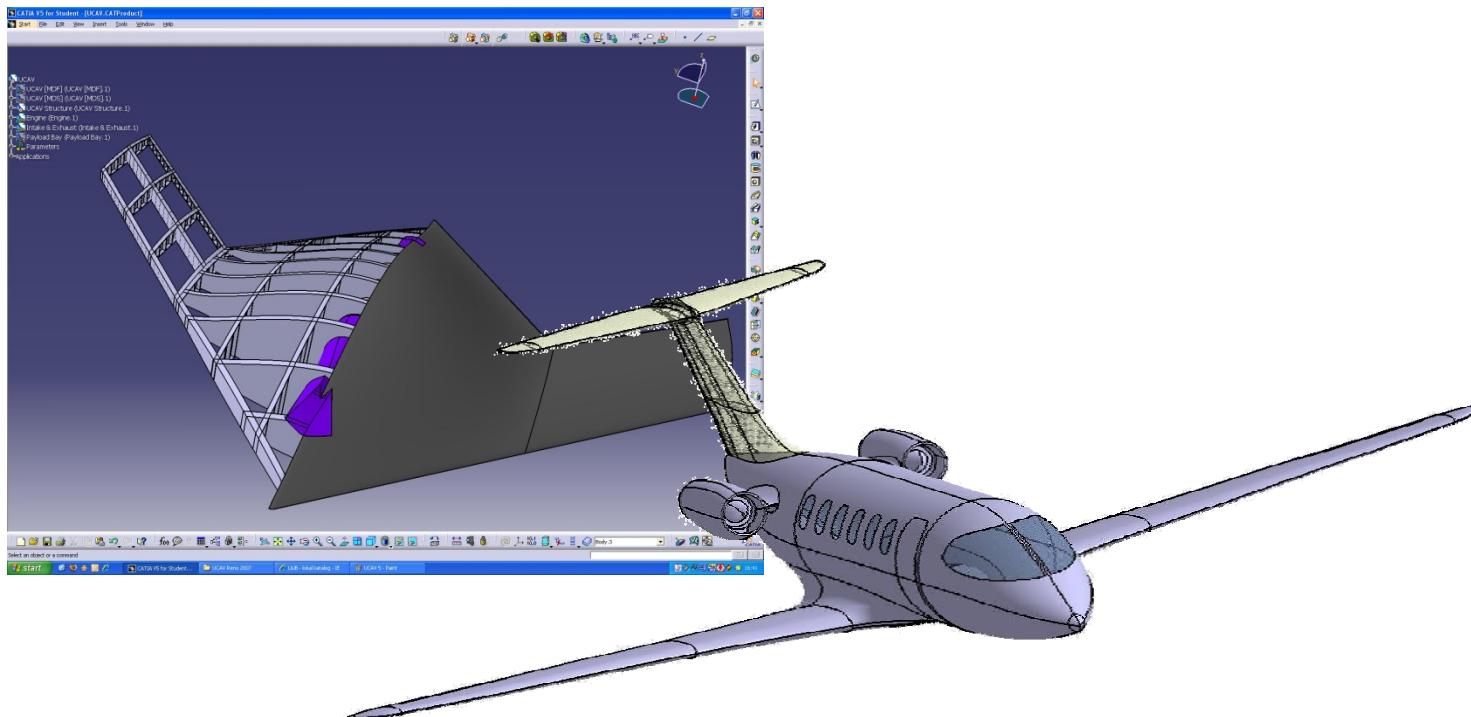


Integrated system analysis of an aircraft with both a aerodynamic model and a simulation model

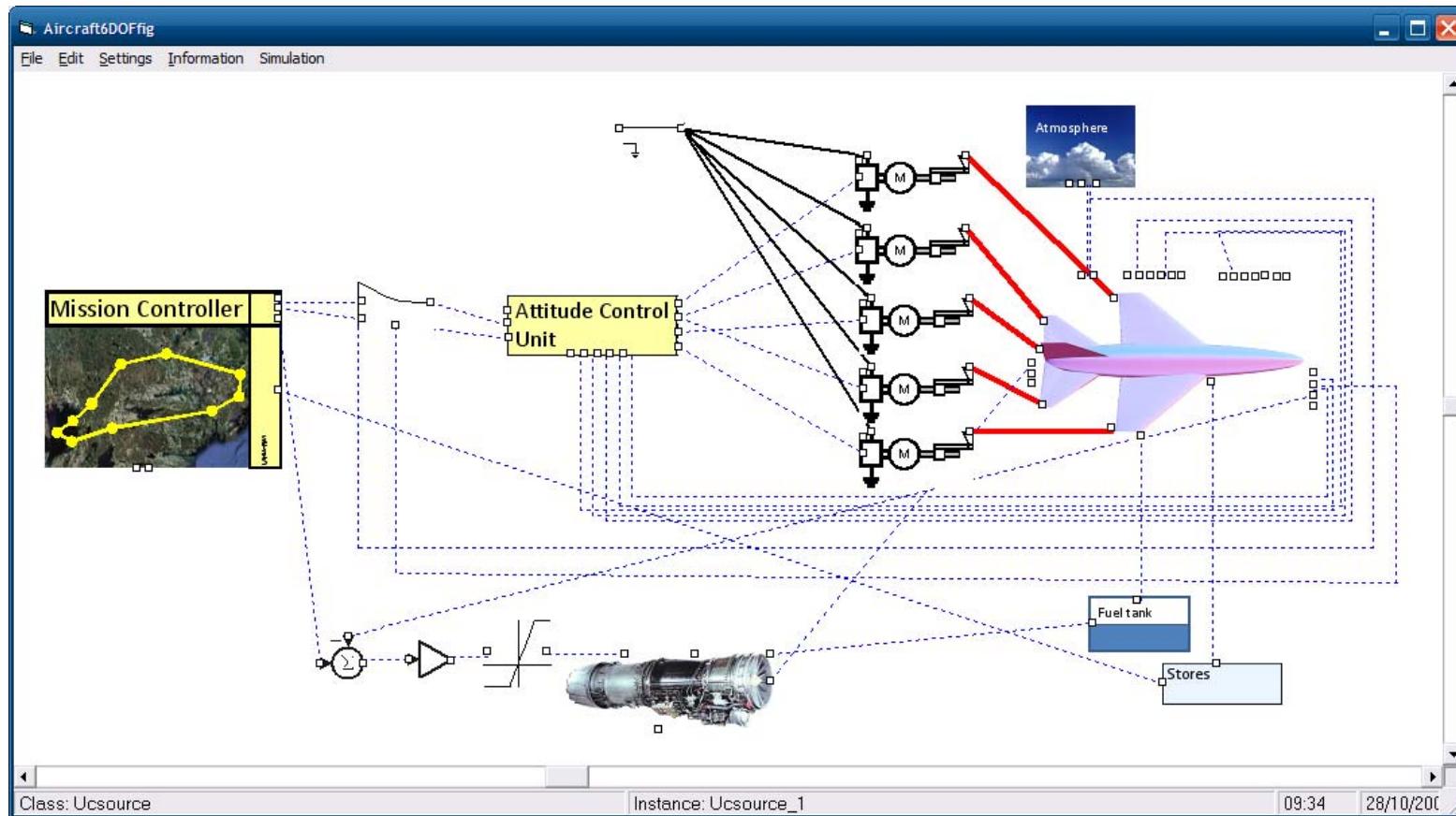


CAD-Design Automation, Knowledge Based Engineering.

Develop methodologies for next generation CAD-software



Full Mission Simulation for Aircraft Design



Towards Full Mission Simulation for Aircraft Design

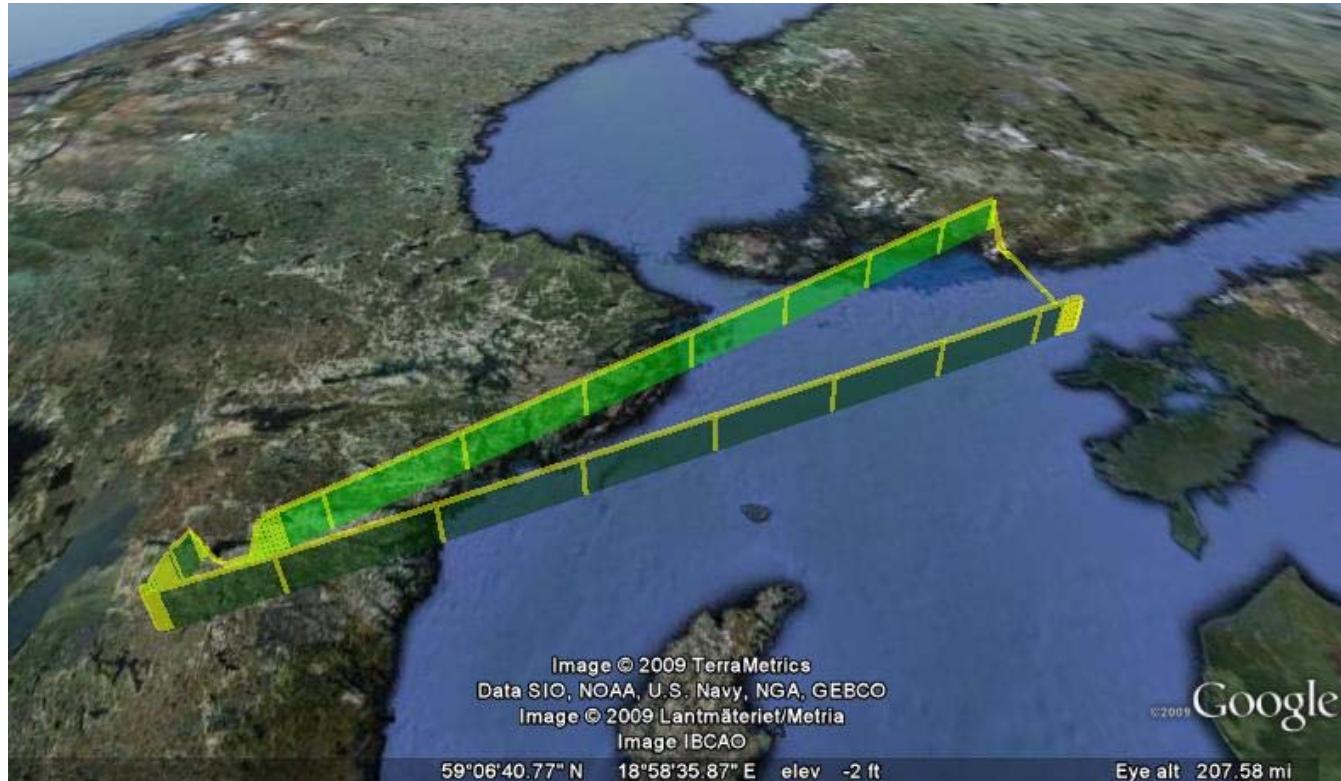


Figure 5. Simulated flight path (Furthest distance about 45 km from start point). Altitude scale is amplified 20 times for the plotting.

(6000 sec simulated in 105 seconds (normal PC), time step 0.01 sec)

Simulation in Heavy Vehicles



Project Examples

- Energy Efficient Hydraulic System (Volvo CE, Parker)
- Hybrid Systems (Volvo CE)
- Sensorsystems for Trucks (Scania)
- Advanced Trajectory control (Scania)
- Aircraft Systems (Airbus Saab)
- Design Optimisation for Industrial Robots (ABB)
- High Speed Simulation (Volvo CE, Atlas Copco, CybAero, Prevas, National Instrument)

High Speed Simulation for Product Design and Operation - HiPO

-Using the same models throughout the lifecycle

System level design

System simulation for design optimization and analysis
High Speed Simulation HSS

Human in the loop simulation,
Real time simulation RTS

Subsystem design

System simulation for design *HSS*

Hardware in the loop simulation
HWIL, RTS

Prototype testing and evaluation

Dynamic testing using
HWIL, RTS

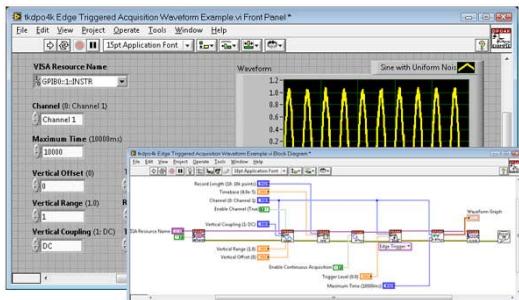
Operation

Training simulators, *RTS*

Embedded simulation models for condition monitoring and control
RTS and faster than real time simulation, FRTS

Mission planning
Faster than real time simulation, FRTS

Industrial Partners and Applications



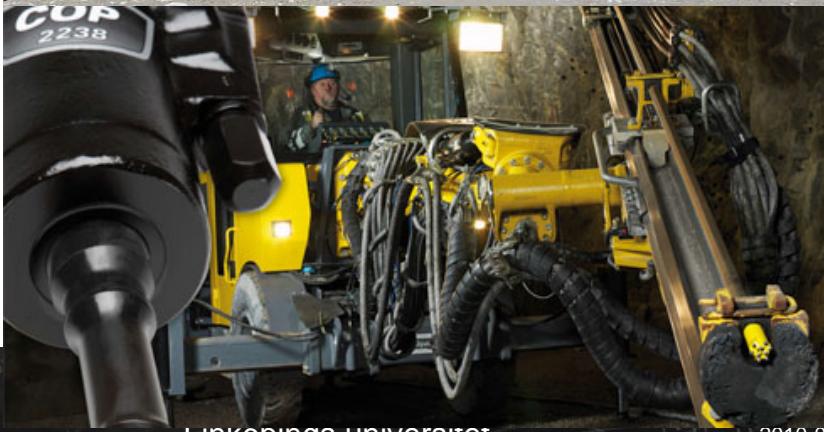
Hardware in the loop
systems
Prevas,
National Instrument



Helicopters
Cyb'aero AB

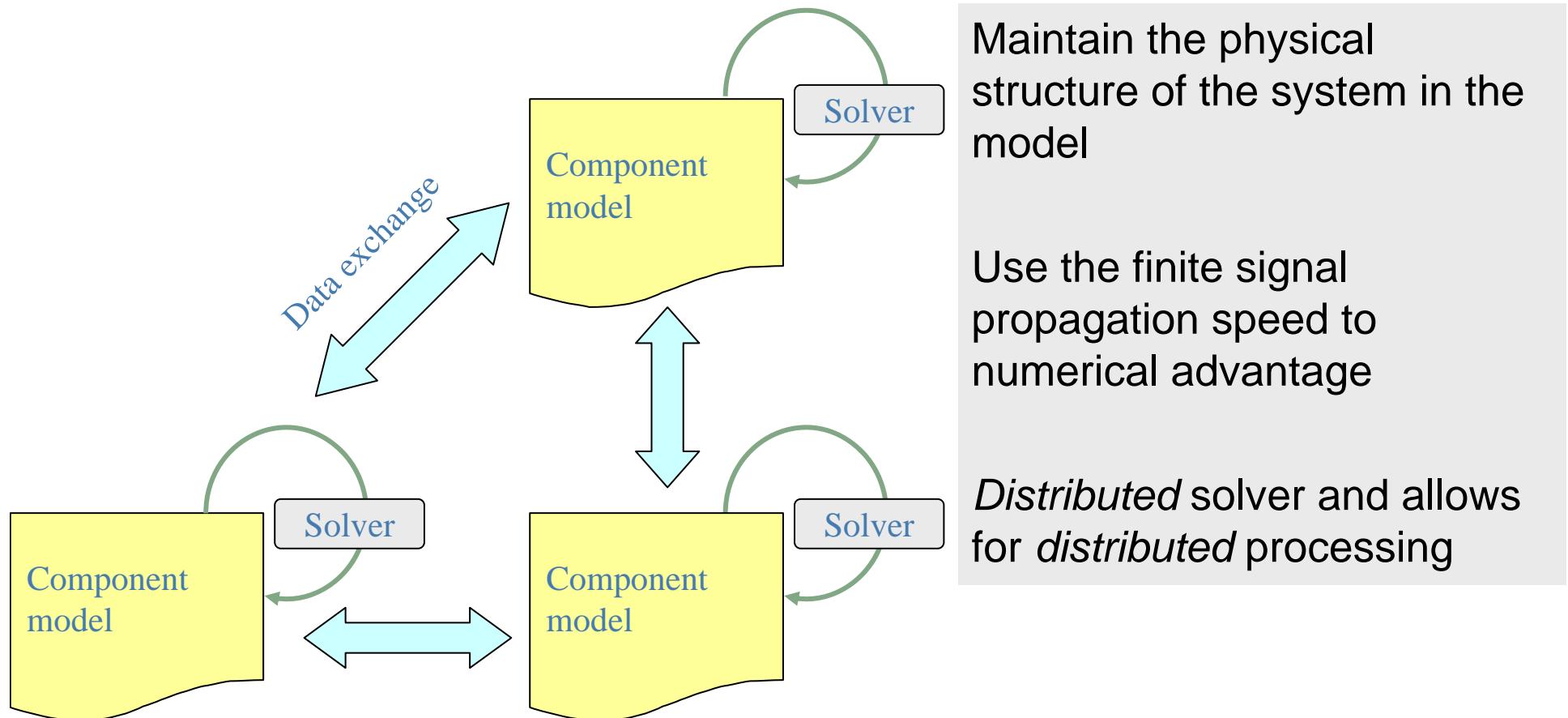


Construction
Machines
Volvo CE



Rock drills
Atlas Copco

Distributed modelling using transmission lines



From sketch to physical prototype in 5 months

The collage illustrates the workflow from initial concept to final product:

- Sketch:** A hand-drawn sketch of the aircraft's outline and internal components.
- 3D Model:** A detailed 3D CAD model of the aircraft structure.
- Prototype:** A wooden model of the aircraft built in a workshop.
- Flight:** The prototype aircraft flying in the sky.
- System Architecture:** A block diagram showing the integration of various systems: Objective function, Aerodynamic, Hydraulic system, Flight simulation, Propulsion, Sizing, and Aerodynamic.
- Flight Trajectory:** A 3D plot showing the aircraft's trajectory in the X_cg [m], Y_cg [m], and Z_cg [m] space.
- System Characteristics Table:**

System characteristics	Unit	Target value	Actual value													
			B	C1	C2	Range	Lift-off distance	Landing distance	Takeoff weight	Required weight system	Optimal cruise speed	Landing speed	Stall speed	Emissions	MTBF	Cost
Range	km	5000,00	5490,87	20,00	6,89	2,07	5948,77	437,66	120,30	84442,66	0,99	147,43	26,48	31,52	52,54	19091
Lift-off distance	m	500,00	393,93	-1,46	-0,37	-0,17	5948,77	437,66	120,30	84442,66	-0,02	-0,12	-0,05	-0,09	-0,09	0,22
Landing distance	m	500,00	104,18	-0,37	-1,32	-0,32	5948,77	437,66	120,30	84442,66	-0,15	-0,08	-0,27	-0,22	-0,22	0,22
Takeoff weight	N	60000,00	85865,23	0,00	0,00	0,00	5948,77	437,66	120,30	84442,66	-0,19	-1,81	-1,00	-0,61	-0,65	0,00
Required weight quotient		1,00	0,98	0,08	-0,03	-0,01	5948,77	437,66	120,30	84442,66	0,59	-0,24	-0,29	-0,70	-0,65	-0,50
Optimal cruise speed	m/s	100,00	146,68	-0,68	-0,11	-0,07	5948,77	437,66	120,30	84442,66	0,26	-0,22	-0,08	-0,29	-0,24	-0,00
Landing speed	m/s	70,00	25,48	-0,50	-0,38	-0,12	5948,77	437,66	120,30	84442,66	0,00	-1,09	-1,00	-0,25	-1,43	0,00
Lift-off speed	m/s	70,00	30,33	-0,50	-0,38	-0,12	5948,77	437,66	120,30	84442,66	0,00	1,00	1,00	0,25	0,19	0,00
Stall speed	m/s	80,00	50,55	-0,50	-0,38	-0,12	5948,77	437,66	120,30	84442,66	0,00	1,00	1,00	0,25	0,19	0,00
Emissions	kg	10000,00	18869,74	0,00	0,00	0,00	5948,77	437,66	120,30	84442,66	0,00	1,00	1,00	0,00	1,00	0,00
MTBF	hour	1000,00	7324,98	0,00	0,00	0,00	5948,77	437,66	120,30	84442,66	0,00	4,27	0,00	1,00	5,27	0,00
Cost	kEUR	40000,00	57060,64	0,00	0,00	0,00	5948,77	437,66	120,30	84442,66	0,00	0,77	0,24	0,02	1,02	0,00
- Scatter Plot:** A scatter plot showing UAV weight versus the number of simulations.
- Final Prototype:** A photograph of the completed white-painted aircraft prototype standing on a grassy field.

2008 *GlobaLiTH*

Light electric utility vehicle for development countries



13:34:31

System characteristics	Units	Target value	Actual value	18397.90	27816.31	20.00	61.33	System characteristics priorities			
								Motor power	Chassi cost	Safety weight	Battery weight
Range	km	40.00	46.89	-0.07	0.14	-0.07	0.76	1.26			
Acceleration (0-70)	s	8.00	5.44	0.06	-0.14	0.08	0.24	1.12			
Top speed	km/h	100.00	135.76	-0.02	0.05	-0.02	-0.08	1.12			
Recharge time	As Y	1.00	1.00	0.00	0.00	0.00	0.00	0.89			
Handling	As X	1.00	1.00	-0.10	0.20	-0.11	-0.34	1.71			
Safety level	As X	1.00	1.00	0.00	0.00	0.95	0.00	0.89			
Running cost/km	EUR/km	2.00	0.11	0.07	-0.14	0.07	0.23	0.45			
Emissions	As Y	1.00	0.00	0.00	0.00	0.00	0.00	1.12			
Cost	SEK	50000.00	58804.53	0.44	0.47	0.00	0.09	0.45			
								System parameters priorities			
								0.58	1.00	1.28	2.03

Winners of Formula ATA Electric and Hybrid Vehicles, Class 2, Rome 2009.



Linköpings