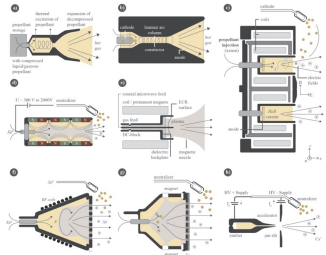
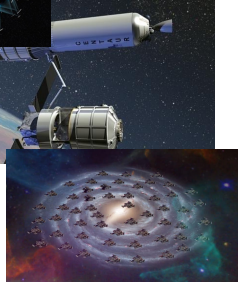


Design / Technology

Mission / business



2)



1)

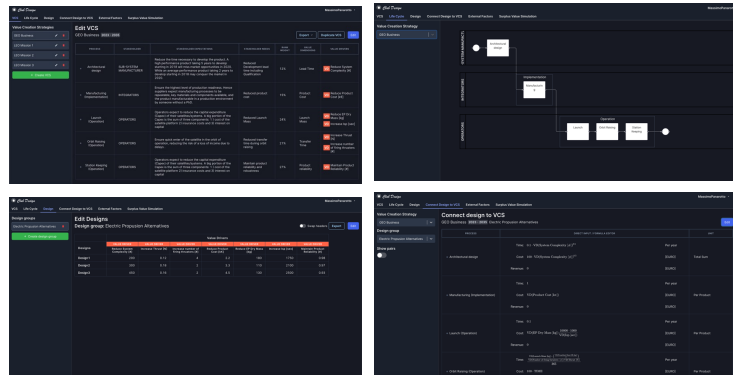
New disruptive concepts, both

- in the technology
- in the mission/business domain

However, the comparison between these radical concepts is difficult today, (due to **different parameters, scales and governing logics** among the alternatives).



Club Design



A **web-based tool** to conduct cost-benefit analysis of design and business alternatives within the electric propulsion business.

The use of the tool is demonstrated in a case study related to hall effect thrusters for geostationary communication and LEO mega-constellations.



The results point at the **flexibility of the tool** to run extensive and **automated digital experiments for both mission/ business and design**, fostering collaborative decision making between business and engineering.

Sources of figures:

- 1) Holste, K., Dietz, P., Scharmann, S., Keil, K., Henning, T., Zschätzsch, D., ... & Klar, P. J. (2020). Ion thrusters for electric propulsion: Scientific issues developing a niche technology into a game changer. Review of Scientific Instruments, 91(6), 061101.
- 2) https://www.esa.int/ESA_Multimedia/Images/2019/11/Mega-constellation_coverage

1. Define Value Creation Strategy

expectations as expressed by the stakeholders. Stakeholder expectations can be of any format, granularity or detail

List of lifecycle processes, adapting ISO 15288 standard. This link is what will enable the cost/benefit simulation

PROCESS	STAKEHOLDER	STAKEHOLDER EXPECTATIONS	STAKEHOLDER NEEDS	RANK WEIGHT	VALUE DIMENSIONS	VALUE DRIVERS
Architectural design	SUB-SYSTEM MANUFACTURER	Reduce the time necessary to develop the product. A high performance product taking 5 years to develop starting in 2018 will miss market opportunities in 2020. While an average performance product taking 2 years to develop starting in 2018 may conquer the market in 2020.	Reduced Development lead time including Qualification	12%	Lead Time	Reduce System Complexity [#]
Manufacturing (Implementation)	INTEGRATORS	Ensure the highest level of production readiness. Hence suppliers expect manufacturing processes to be repeatable, key materials and components available, and the product manufacturable in a production environment by someone without a PhD.	Reduced product cost	15%	Product Cost	Reduce Product Cost [k€]
Launch (Operation)	OPERATORS	Operators expect to reduce the capital expenditure (Capex) of their satellites/systems. A big portion of the Capex is the sum of three components: 1) cost of the satellite platform 2) insurance costs and 3) interest on capital	Reduced Launch Mass	24%	Launch Mass	Reduce EP Dry Mass [kg] Increase Isp [sec]
Orbit Raising (Operation)	OPERATORS	Ensure quick enter of the satellite in the orbit of operation, reducing the risk of a loss of income due to delays .	Reduced transfer time during orbit raising	21%	Transfer Time	Increase Thrust [N] Increase number of firing thrusters [#]
Station Keeping (Operation)	OPERATORS	Operators expect to reduce the capital expenditure (Capex) of their satellites/systems. A big portion of the Capex is the sum of three components: 1) cost of the satellite platform 2) insurance costs and 3) interest on capital	Maintain product reliability and robustness	27%	Product reliability	Maintain Product Reliability [#]

A Value Creation Strategy (VCS) is a set of rank-weighted Needs that have to be satisfied. Changing the needs will allow us to define a new business scenario/mission. No design is created yet.

Value drivers: What engineering aspects impact this need - that you can control during design?

From the VCS view, a design table is created automatically.

The values for the different alternatives can be set manually, or can be imported from Excel if simulations have been run with other tools.

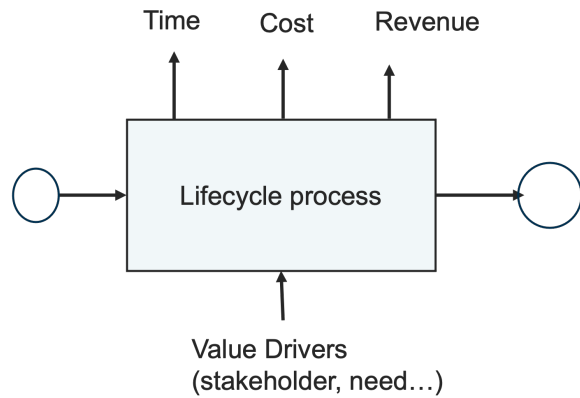
2. Create Designs

The screenshot shows the 'Edit Designs' interface for the 'Electric Propulsion Alternatives' design group. It features a table with columns for 'Designs' and seven 'VALUE DRIVER' categories. The data is as follows:

Designs	Reduce System Complexity [#]	Increase Thrust [N]	Increase number of firing thrusters [#]	Reduce Product Cost [k€]	Reduce EP Dry Mass [kg]	Increase Isp [sec]	Maintain Product Reliability [#]
Design1	200	0.12	4	2.2	180	1750	0.98
Design2	300	0.18	2	3.3	110	2100	0.97
Design3	450	0.16	2	4.5	130	2500	0.93

More radical designs can be created and analysed (through the create new design group function).

For each pair of mission and design, a set of relationships between the value drivers and the time, cost and revenue for each process can be defined



This link is what will enable the cost/benefit simulation

3. Connect Design to VCS

PROCESS	DIRECT INPUT / FORMULA EDITOR	UNIT
Architectural design	Time: $0.1 \cdot VD(\text{System Complexity } [\#])^{0.5}$	Per year
	Cost: $100 \cdot VD(\text{System Complexity } [\#])^{0.5}$	[EURO]
	Revenue: 0	[EURO]
Manufacturing (Implementation)	Time: 1	Per year
	Cost: $VD(\text{Product Cost } [k€])$	[EURO]
	Revenue: 0	[EURO]
Launch (Operation)	Time: 0.1	Per year
	Cost: $VD(\text{EP Dry Mass } [kg]) \cdot \frac{10000 - 1000}{VD(\text{Isp } [sec])}$	[EURO]
	Revenue: 0	[EURO]
Orbit Raising (Operation)	Time: $\frac{VD(\text{Launch Mass } [kg]) - \frac{VD(\text{Prevalent Mass OR } [kg])}{2}}{VD(\text{Number of firing thrusters } [\#]) \cdot VD(\text{Thrust } [N])}$	Per year
	Cost: $100 \cdot \text{TIME}$	[EURO]
	Revenue: 0	[EURO]

4. Run Surplus Value Simulation

the model optimizes the combined profit of the customer, the manufacturer and eventual suppliers (i.e. the combined profit of an imaginary corporation that performs all three roles).

the simulation allows to understand the impact of the design alternatives on the **cost-revenue profiles over time for each mission.**



the simulation allows to **confirm or disconfirm the initial rank-weight set in the value creation strategy** (e.g. in the trade-off among thrust and Isp)

Option 3 is the one that allows to generate higher revenues, due to its high thrust (**earlier enter in orbit**) and **relatively low mass**). However, **the pay back is longer due to its higher complexity** (a more innovative and risky concept).