

MASAI



DESIGN TO COST

Prometheus : Precursor of new low-cost rocket Engine

SCEC Presentation

October 2, 2026 – v01

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Context and goals



Context

PROMETHEUS (Precursor Reusable Oxygen Effective cost Methane Engine)

- Precursor of a flexible engine family concept
- Thrust of 1000KN as the result for rationalization
- Liquid methane & oxygen
- Reusability for launch service flexibility
- Demonstration, initiated by CNES and ArianeGroup, running in the frame of the ESA Future Launchers Preparatory Program since 2017

Ambitious 1M€ Recurrent Cost target to be competitive, associated to high production rate

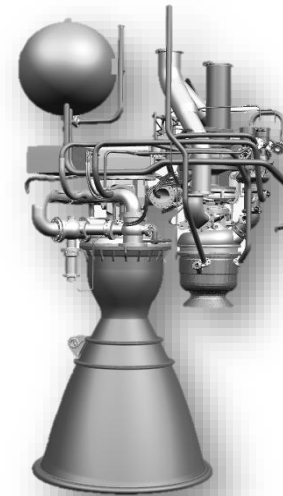
This ambition trickles down to all sub-systems, starting with the REEC (the electronic unit used regulate and control the engine)



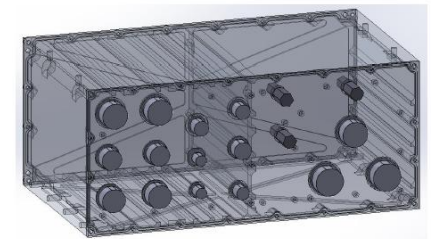
Involved parties

To close in on cost target, while keeping a close eye on performance and schedule, brings together multiple parties :

- CNES : sponsor
- ArianeGroup : design lead and client
- SERMA : design and manufacturing sub-contractor
- Masai : consulting firm specializing in economic performance and Design to Cost



Prometheus Engine



REEC

Why apply D2C to engine Controller ?



You can not just buy the brain of the engine !

The controller had to be worked methodically with our partner to cut RC first & keep NRC and schedule in every trade.

Software	Valves C&C	Operating point	Sensor power	Acquisition	Launcher link	Failures	Recording
Laws and logic	Every valve	Thrust, MR, Start & Stop	Power & condition	Sensor suite	Vehicle comms	Detect & isolate	Flight parameters
<div> <div> This is where regulation takes place <p>Valves command, thrust and mixture ratio control, sensors, launcher link: all that is done through the engine controller.</p> <p>Its architecture and design choices are strongly linked the engine's recurring cost.</p> </div> <div> Every requirement has a price <p>How many sensors? Which failures are flagged? What is recorded? Which protocol?</p> <p>Each line in the spec writes hardware, software and lead time.</p> <p>Unpack it before it freezes.</p> </div> <div> One choice can own the bill <p>A sample rate, a radiation grade, one extra channel, a closed-loop law... Name the drivers!</p> <p>If not, expensive details may arise after CDR, when nothing can move.</p> </div> </div>							
<div> <div> Build the understanding in layers <p>Functions, then requirements, then drivers, then alternatives.</p> <p>A cost target set without that sequence is a wish.</p> <p>Heritage is what you get if you skip a layer.</p> </div> <div> Neither sides sees the whole unit <p>The client holds the engine, reusability and the vehicle interface.</p> <p>The supplier holds electronics, manufacturing yield, software and qualification.</p> <p>Alone, each party would specify or design the wrong REEC.</p> </div> <div> The design appears in the middle <p>The solution that cuts unit cost while preserving NRC or schedule is the one both sides can see by sharing a common view of PBS.</p> <p>That's the win-win.</p> <p>A « pure » price discussion cannot reach it</p> </div> </div>							



The mastering of cost for development and production in space transportation is essential to enable the deployment of increasing space applications.

Propulsion is one of the major contributor to space transportation. Beyond classical technical challenge associated to engine development, two important constraints were imposed to the development of the Prometheus engine :

- at first reducing by an order of ten with respect to historical engine its production cost
- in second optimizing the engine cost contribution to the global recurring cost of space transportation with the implementation of reusability

The design to cost is a well known method at ArianeGroup. Masai has the expertise in design to cost methodology

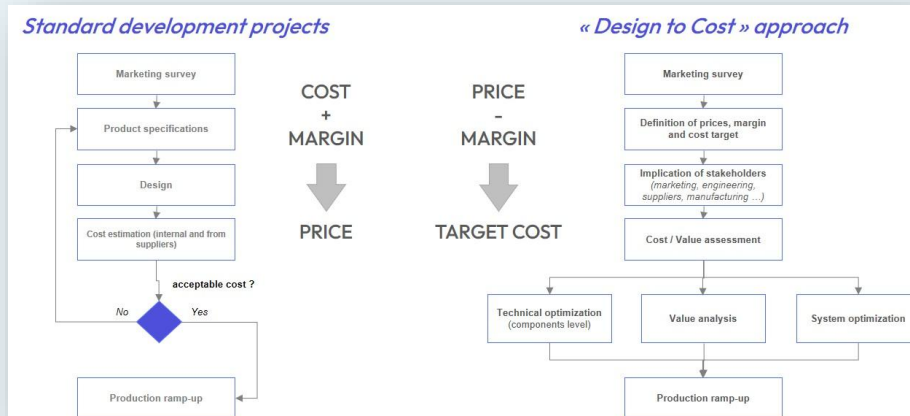
CNES has made it possible to apply a deeper “Design to Cost” approach to a subsystem: the Rocket Engine Electric Command (REEC)

Design to Cost (D2C)

Key concepts



Paradigm shift in project mindset and focus

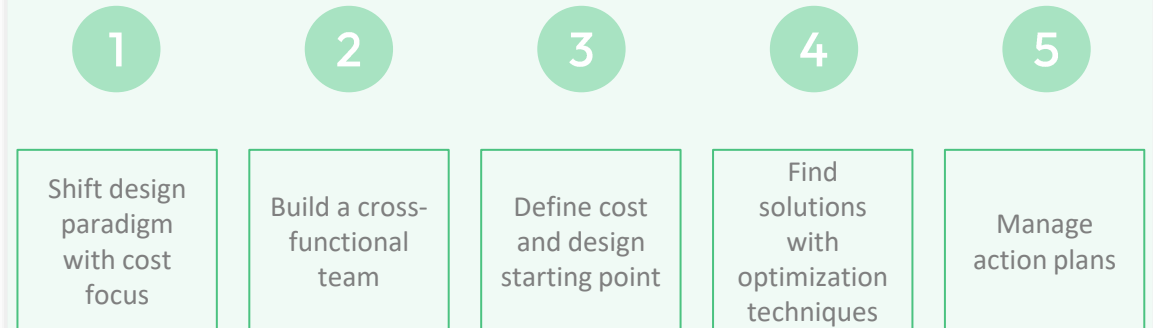


D2C is about finding the right balance between cost and value

Technical solutions are sought to meet market expectations, not the other way around



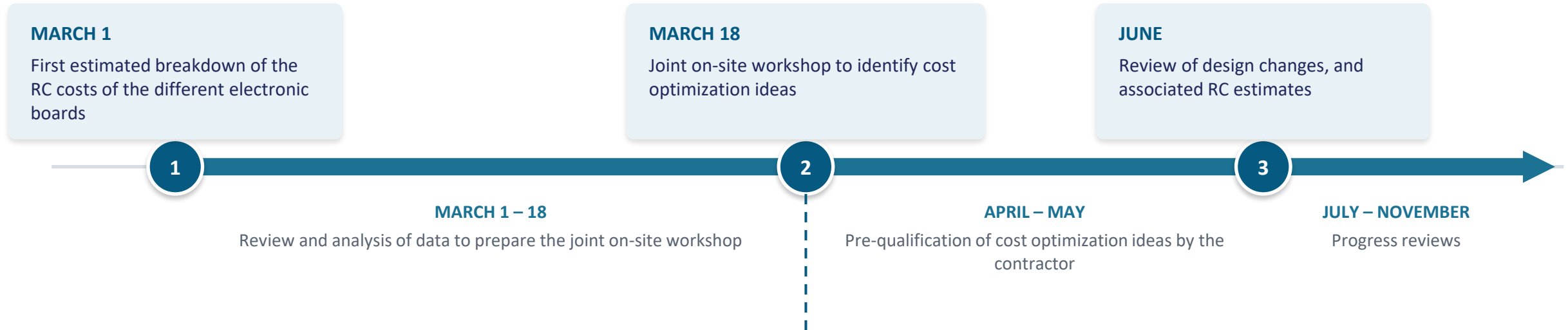
5 key steps to perform



D2C requires early and continuous involvement of all stakeholders

Setting the right target is key to meeting it

Main steps and activities



Workshop objectives

- Break down costs as much as possible (material or components, labor, NRC, ...)
- Determine the sizing parameters (cost drivers) of key components
- Take into account the impacts at the interfaces (rest of the instrumentation and engine)
- Understand the reasons for the technical choices made, and put them into perspective in the present context
- Analyze technical and economic alternatives and estimate their costs

Results

The collaboration between Serma and ArianeGroup allowed for significant achievements

- Obtaining a detailed breakdown of the initial recurring costs for the REEC
- Optimization opportunities with a potential cost saving of -20%

Presentation of interim results to key ArianeGroup players in the program generated strong interest in the approach and the associated cost savings potential

Lessons learned – Areas of attention



Heavy collaboration framework

The tripartite NDA was long and difficult to set up. Part of the team initially saw it as an extra constraint on teams already stretched on technical scope and deadlines.



“We already factor in cost”

Design teams believe costs are already considered, since they apply what feels to them like common economic sense when designing.



Industry standards & mindset are not always compatible with D2C



Technical first

Technical issues prevail over financial considerations.



Quality > deadline > cost

Extra cost is more acceptable than technical failure or delay.



TCO is hard to grasp

The Total Cost of Ownership view is difficult to apply at subsystem level and for suppliers.



Cost knowledge is seen as peripheral

Understanding costs and cost drivers is viewed as an additional task, at the periphery of the design project itself.



Bottom line: this context makes it difficult to collaborate with suppliers on a technical and economic basis.

Why it pays off, what it takes to make it work



Benefits of Embedded D2C



Secures deadlines

Surfaces opportunities upstream of the project, anticipating unpleasant surprises before they hit the schedule.



Avoids costly late-stage loops

Early cost estimation heads off nasty surprises — and expensive rework — at the end of the project.



Aligns all stakeholders early

A multi-disciplinary team including the supplier(s) from the design stage captures everyone's constraints.



Faster than requesting quotes

Sharing and estimating costs together is a significant time saver compared to seeking quotes on finished plans.



Prerequisites



Strong sponsorship, client & supplier

Management conviction that open cost-sharing (not just prices) is win-win, a clear contractual framework with concrete incentives, and engagement as early as possible.



Cost breakdown shared on an ongoing basis

Every design proposal comes with a cost estimate, whatever its precision — built on assumptions whose limits and uncertainties are made explicit and resolved over time.



A culture propagated across the value chain

D2C principles and curiosity about costs must be explained and spread to subcontractors and the whole value chain, in the industry's common interest.