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New innovative anti-tank solid rocket motor design

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Abstract

Since the early 2000's Roxel, formely Celerg, have tried to promote advanced technologies in its solid rocket motor designs for tactical missiles. More particularly, cooperation with SNPE, in charge of DGA funded research, was performed to demonstrate interest in smokeless XLDB propellant such as Azamite®.

Through new impulse given by its new shareholder SAFRAN Herakles and MBDA financial support, industrials partners set up late 2011 an ambitious technical demonstration program enabling Roxel, European leader company, to demonstrate its technical and industrial ability in providing solid rocket motor design including lead free smokeless XLDB propellant and more particularly Azamite®.

Compared to smokeless conventional of the shelf technologies Azamite®propellant combined with appropriate single charge design is able to provide,

- Environmentally friendly solution (lead free),
- Higher specific impulse, higher Turn Down Ratio enabling to extend missile range,
- Comparable costs of production,

By merging their resources and efforts, the industrial partners, with a large range of simulation works, experimentations and trials, aim to demonstrate,

- Achievable ballistic performances at SRM level on a large temperature range,
- SRM Safety factors including knock down factor associated with ageing,
- IM performances,
- Plume signature,

After first promising firing trials achieved in heavy weight and solid rocket motor configurations, TRL6 is expected to be reached by the end of 2015, and allow to go on with development program for an updated MMP solid rocket motor design which could be delivered to forces around 2020.

Such achievement will enable Roxel and its partners to expand their technological portfolios, propose this innovative technology in all new development programs in which performance is required, and stay a step ahead from competitors.

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1. Introduction

Early 2010, replacement of MILAN (middle range) anti-tank missile was confirmed. MBDA, major missile prime, proposed in this way to set MMP development and qualification program in order to provide French forces a fire and forget anti-tank missile.

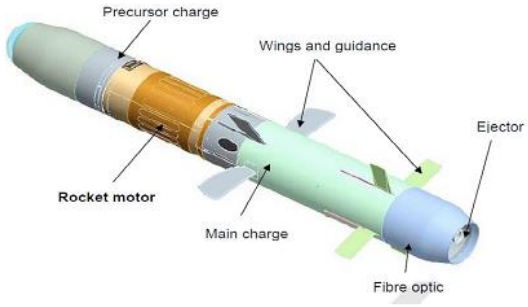

Illustration 1 : MMP missile architecture

This new program was considered as a new opportunity to promote Herakles and Roxel past experiences in respectively advanced energetics and innovative solid rocket design such as Nitramite® propellant development in the early 90's, MACAM (Tow anti-tank solid rocket motor Europeanisation) and Diabolo (anti-tank boost-sustain Azamite® R free standing grain) advanced research programs.

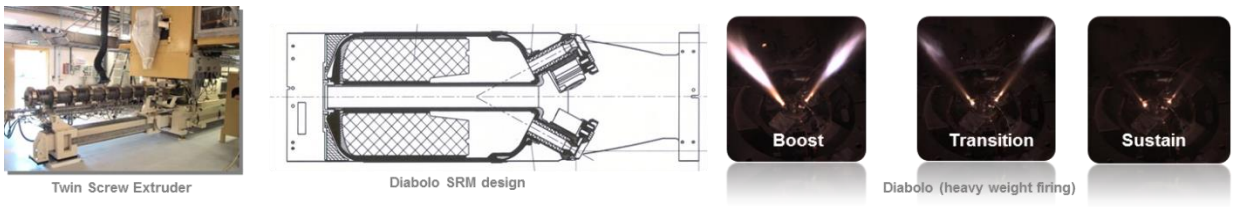

Illustration 2 : Diabolo Advanced Research program

Moreover, this new program was considered as a chance to speed up performances demonstration of **minimum smoke lead free Azamite ®R propellant** already known to provide higher specific impulse than conventional double base (EDB, CDB and XLDB).

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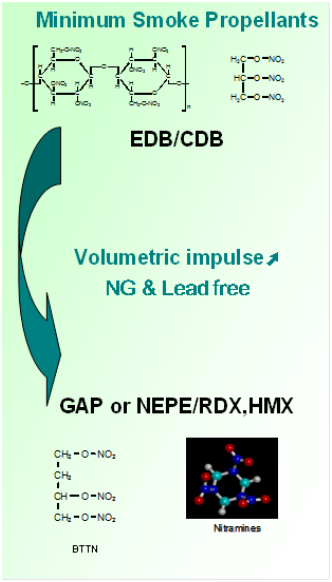

Illustration 3 : Lead free Azamite® R formulation drivers

To accelerate double base technology substitution currently down selected in the development program, industrial partners decided to set up a technology demonstration program base on lead free Azamite® R propellant, enabling the team to demonstrate compliance with MMP SRM specifications.

By demonstrating capability to achieve, boos-sustain ballistic regime, MURAT one star signature, shelf life, plume transparency, and cost performance, the partners aim to achieve TRL 6 late 2015 to propose prime, government and forces the best available technology providing extended (range, missile agility,….) performances compared to off the shelf systems.

2. Technological demonstration, key achievements to date.

Lead free Azamite® R propellant was developed through DGA funded research program. Lead free Azamite® R performances evaluation coupled with past experience analysis eased to design reliable grain and solid rocket motor architecture.

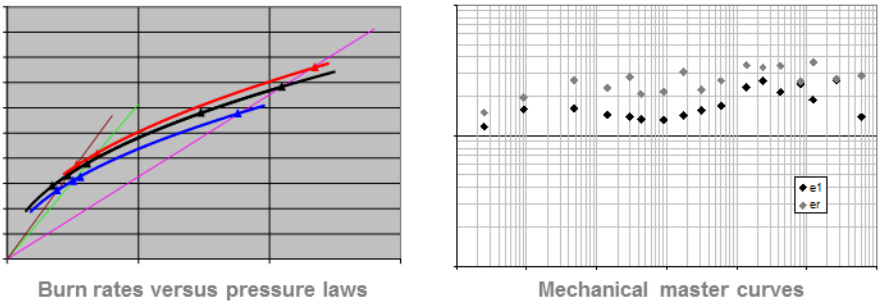

Illustration 4 : Lead free Azamite® R performances

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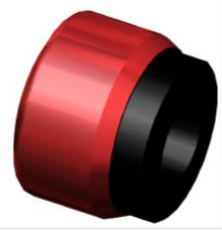
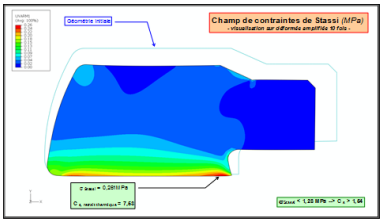
Azamite® R performances were then integrated in trade off studies to predict performances and analyse them in regards with MMP technical specifications.





SRM Safety factor- Thermal cool down

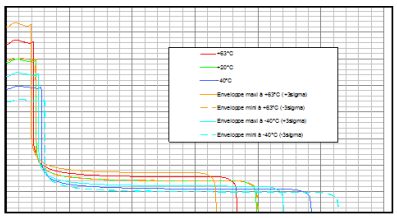

Thrust versus time laws

Illustration 5 : boost-sustain charge design and associated performances

In the early step of the demonstration program, plume signature was appraised. Combined with dedicated inhibition system, Azamite® R propellant demonstrated the compliance with the required level of stealth, both for visible and infra-red transparencies. Moreover, use of formulation additives and dedicated nozzle conditions lead to non-post combustion phenomenon.

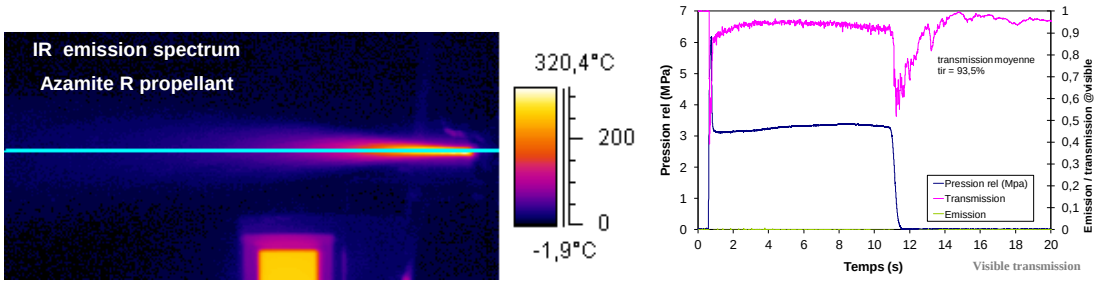


Illustration 6 : plume signature assessment (visible and IR)

Grains were then manufactured on representative industrials means of production in order to provide the necessary stuffs to implement performance demonstration at solid rocket motor level. More than 20 grains were manufactured.

Prior to integrate the grains in Kevlar over wrapped aluminium case, heavy weight firing were successfully achieved allowing the next step of the demonstration program to be implemented.

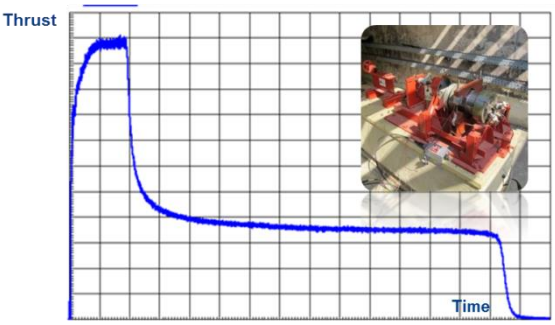


Illustration 7 : Heavy weight firing at +20°C

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Then, SRM demonstrators were successfully performed on the whole temperature range [-40°C to +63°C], demonstrating boost –sustain regimes with a measured thrust down ratio over 3.

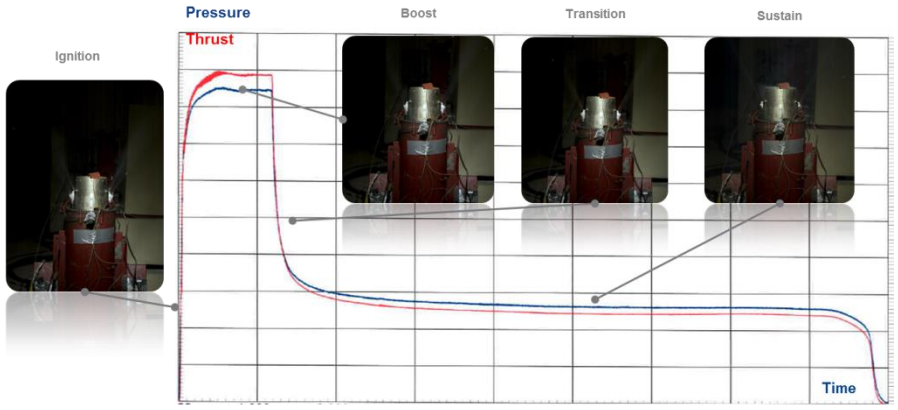

Illustration 8 : example of SRM firing at +40°C

Early 2015, partners considered that achieved TRL is 5. The next steps to come will be focused on IM and ageing knock down factor through simulated ageing program.

Concerning IM, the solid rocket motor signature will be demonstrated by performing slow cook off (3,3°C/h) and fragment impact (1800 m/s) trials. As fully representative in terms on SRM design, Diabolo signature measured for fuel fire and bullet impact will feed the current technical demonstration.

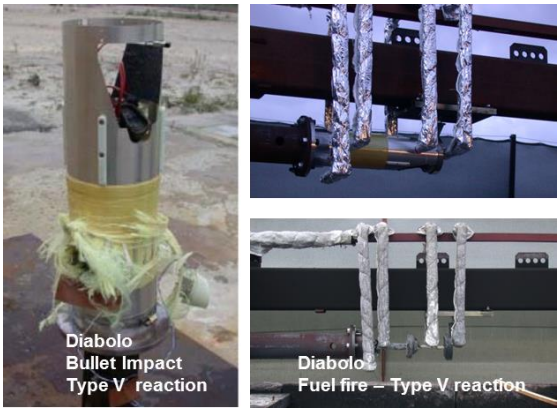

Illustration 9 : IM signature (Diabolo past experience)

3. Industrialisation

Industrialization process began mid 2013, with risk analysis surveys. Through this first step, industrial organization was identified to organize safe production cycle complying with on time, on cost on quality future deliveries.

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In parallel, robust design-rapid development methodology (addressing class of difficulties, maturity level) is implemented to demonstrate industrial capability to qualify the defined design.

4. Conclusions

Through the work completed lead free Azamite® R performances were strengthened on MMP specified temperature range. Boost – sustain grain and solid rocket motor designs were implemented and performance predictions completed in regards with MMP technical specification. This step highlighted possible performances extensions at missile level.

Moreover, industrial partners considered that through heavy weight and SRM firings TRL 5 was achieved on the technology. The next steps at demonstration program level will ease to achieve TRL 6 by the end of 2015 preparing future development and industrialization phases enabling prime to deliver MMP MK2 in the years to come.

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