SMILE - Small Innovative Launcher for Europe

Bertil Oving, Netherlands Aerospace Centre (NLR)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 687242.

Demand

source: SpaceWorks Enterprises Inc (SEI)

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Project

- SMall Innovative Launcher for Europe – SMILE in EU Horizon 2020 framework programme
- 14 companies & institutes from 8 European countries, 4 M€ grant, Jan 2016 – Dec 2018
- Objectives

  1. business development
  2. launcher & ground segment design
  3. demonstration of critical technology

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Consortium

Netherlands Aerospace Centre (NLR)	NL	launcher, structures, avionics, EGSE, cost analysis, project coordinator
INCAS	RO	launcher, aerodynamics, trajectory
Nammo Raufoss AS	N	launcher, hybrid engines, cost analysis
German Aerospace Centre (DLR)	D	launcher, liquid engines, cost analysis
WEPA-Technologies	D	turbopumps: LOX/kerosene, H_2O_2
PLD Space	SP	liquid engine testing
ISIS - Innovative Solutions In Space	NL	business development, market analysis, payload deployment system
Airborne Composites Automation	NL	production methods, structures
Heron Engineering	GR	structural analysis
3D Systems	BE	3D printing of metal parts
Tecnalia	SP	advanced low-weight materials
Andøya Space Centre (ASC)	N	ground segment, market analysis
BoesAdvies	NL	business development, market analysis
Terma	DE	avionics, EGSE

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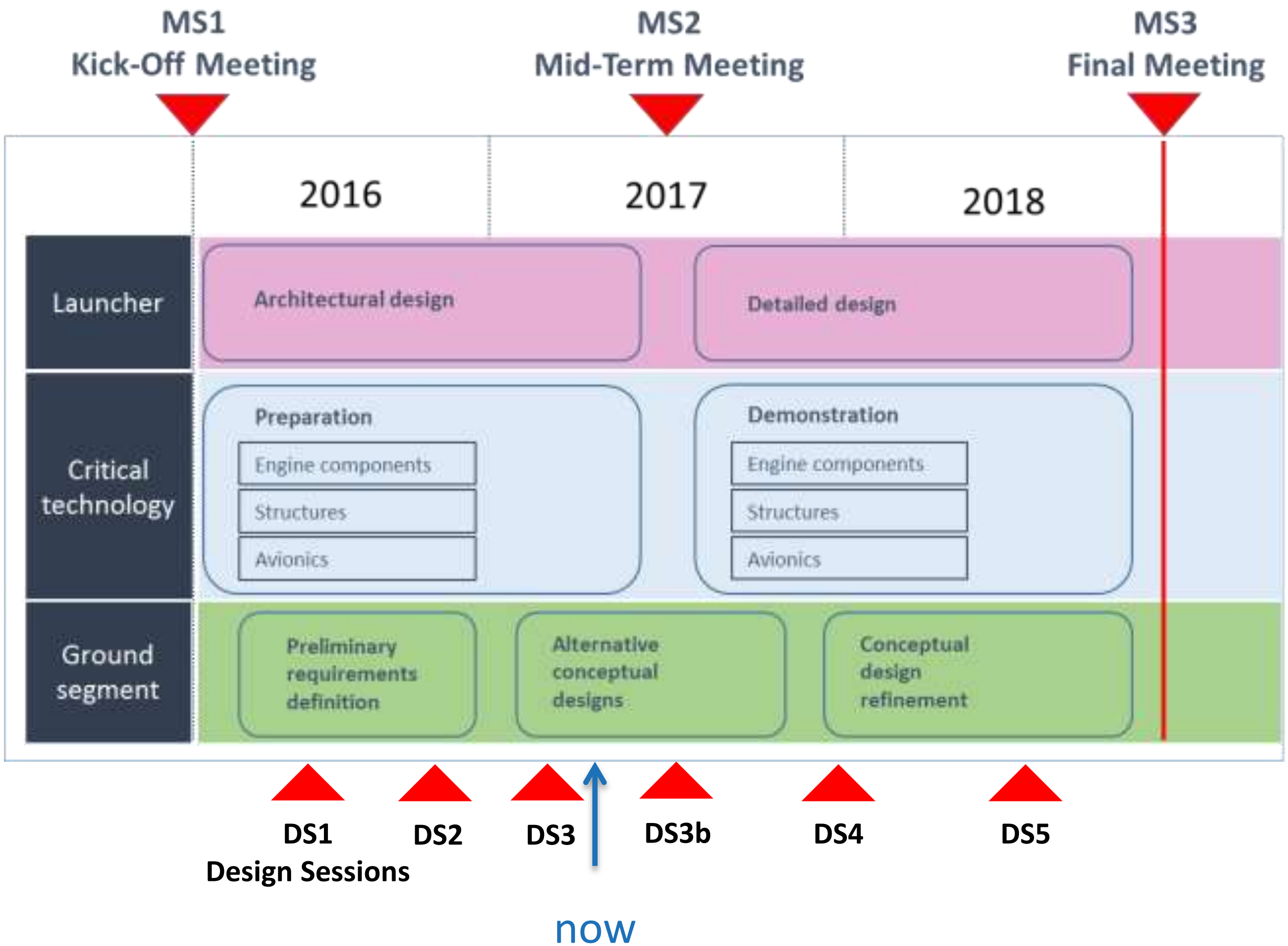
Planning



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Challenge

- Smaller launcher -> lower payload fraction -> impact on revenue -> challenge for ROI
- Focus on **cost-effectiveness**:
  - hybrid HTPB/H_2O_2 *low cost, unitary* hybrid engines
  - liquid LOX/kerosene *reusable, unitary* engines
  - *low cost* turbopumps
  - *automated* production of composite structures
  - *3D printing*
  - *low-cost* avionics using COTS
  - *efficient* ground segment, handling, and operations

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Launcher

- Payload at least 70 kg into 600 km SSO
- Launch from Andøya Space Centre (Norway)
- Competitive price (less than 50k€ per kg)
- Considering various configurations using combination of hybrid and liquid engines
- Towards family of launchers with more capacity than 70 kg

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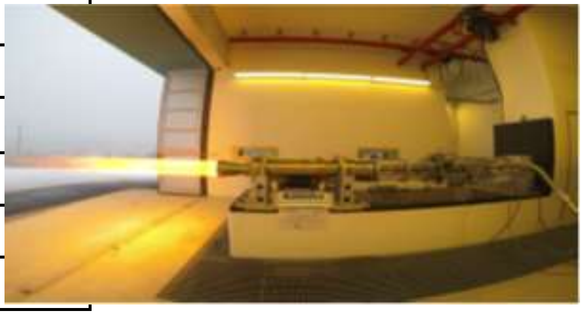
Hybrid Engine

- Unitary Motor (UM) by Nammo Raufoss AS:
  - Oxidizer: Hydrogen Peroxide (H_2O_2)
  - Fuel: Hydroxyl-Terminated Polybutadiene (HTPB)
- Two phases for UM development and test
  1. Heavy-Wall Unitary Motor HWUM (fall 2014)
  2. Flight Weight Unitary Motor FWUM (fall 2015)
- Further mass reduction using composite casing
- Design of H_2O_2 turbopump (with WEPA)

Property	HWUM	FWUM
Total impulse	750 kNs	980 kNs
Outer diameter	305 mm (12 in.)	356 mm (14 in.)
Burn duration	25 s	35 s
Dry mass (without consumed fuel)	>280 kg	<100 kg
Consumed fuel mass	< 50 kg	> 60 kg
Consumed oxidizer mass	~270 kg	~380 kg



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Hybrid Engine

- Self-ignition increases engine start reliability and enables unlimited restart capability
- Wide-range throttling with limited performance loss
- Green life cycle and exhaust properties
- Solid inert fuel and high-density green storable oxidizer
- High combustion efficiency, performance, and stability
- Simplicity of a single circular port and single feedline configuration
- Low development and operational costs with potential for automated production

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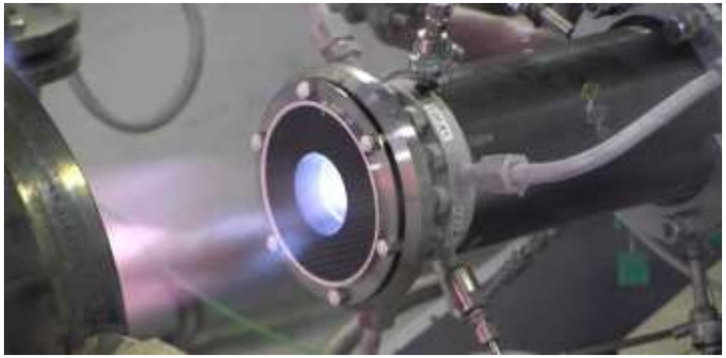
Liquid Engine

- High performance, reliable technology, variable thrust-levels and easily re-ignited
- Liquid engine design by DLR (LOX/LH2 heritage)
- Design of LOX/kerosene turbopump (with WEPA)
- Combination of LOX and kerosene:
  - High-density
  - Low cost
  - World wide available
  - Easy storage and refuelling
  - Green propellants



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Liquid Engine

- Reusability advantage for
  - Ceramic matrix composites (CMC) to improve engine life when thermally cycled without degradation
  - Transpiration cooling (selected by P&W to fulfil NASA req. of 100-time engine reusability in the 1960s)
- Reduction in engine's structural weight by use of
  - Low cost 3D printed components
  - Carbon-Fiber-Reinforced Plastic (CFRP) housing structures
  - Application of SLM techniques (hollow sections)
- Hot firing tests of LOX/kerosene engine at PLD Space (Spain) TRL target: 5/6

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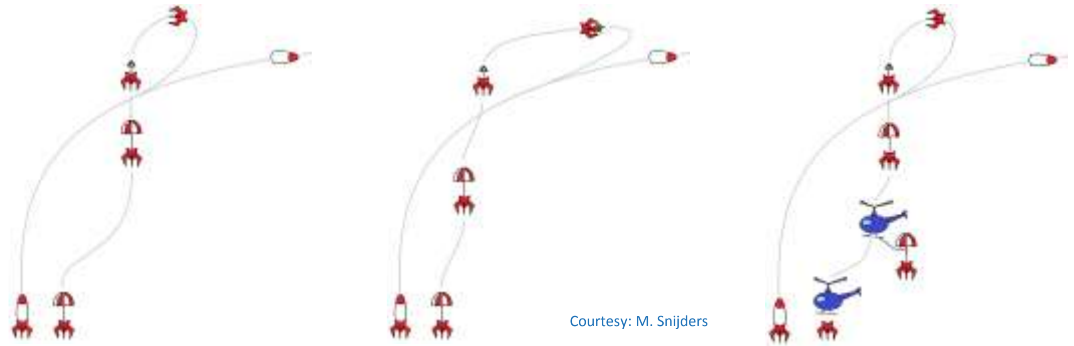
Reuse

- Significant cost reduction through reuse of first stage
- Recovery implies some extra cost
  - Extra mass for recovery system (propellants, parachutes)
  - Retrieval and transport to launch site
  - Inspection



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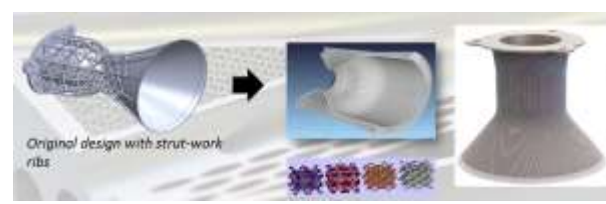
Automation

- Automated lay-up of composites
  - Filament winding
  - Automated tape laying
  - Automated fibre placement
  - Robotic pick & place
  - Braiding
- 3D printed metal parts
  - Both hybrid and liquid engines
  - Structural inserts





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Business Case

- Market analysis
  - Small satellite market history vs outlook scenarios (including pessimistic)
  - Competitors
  - Unique selling points
  - Time-to-market
- Cost-benefit analysis
  - Impact of launch rate, launcher family, and pricing
  - Bottom-up cost estimations
- Recurring cost estimation
  - Manufacturing, assembly, integration, test
  - Supply chain
  - Organisation
  - Operations
- Non-recurring cost estimation
  - Technology roadmaps

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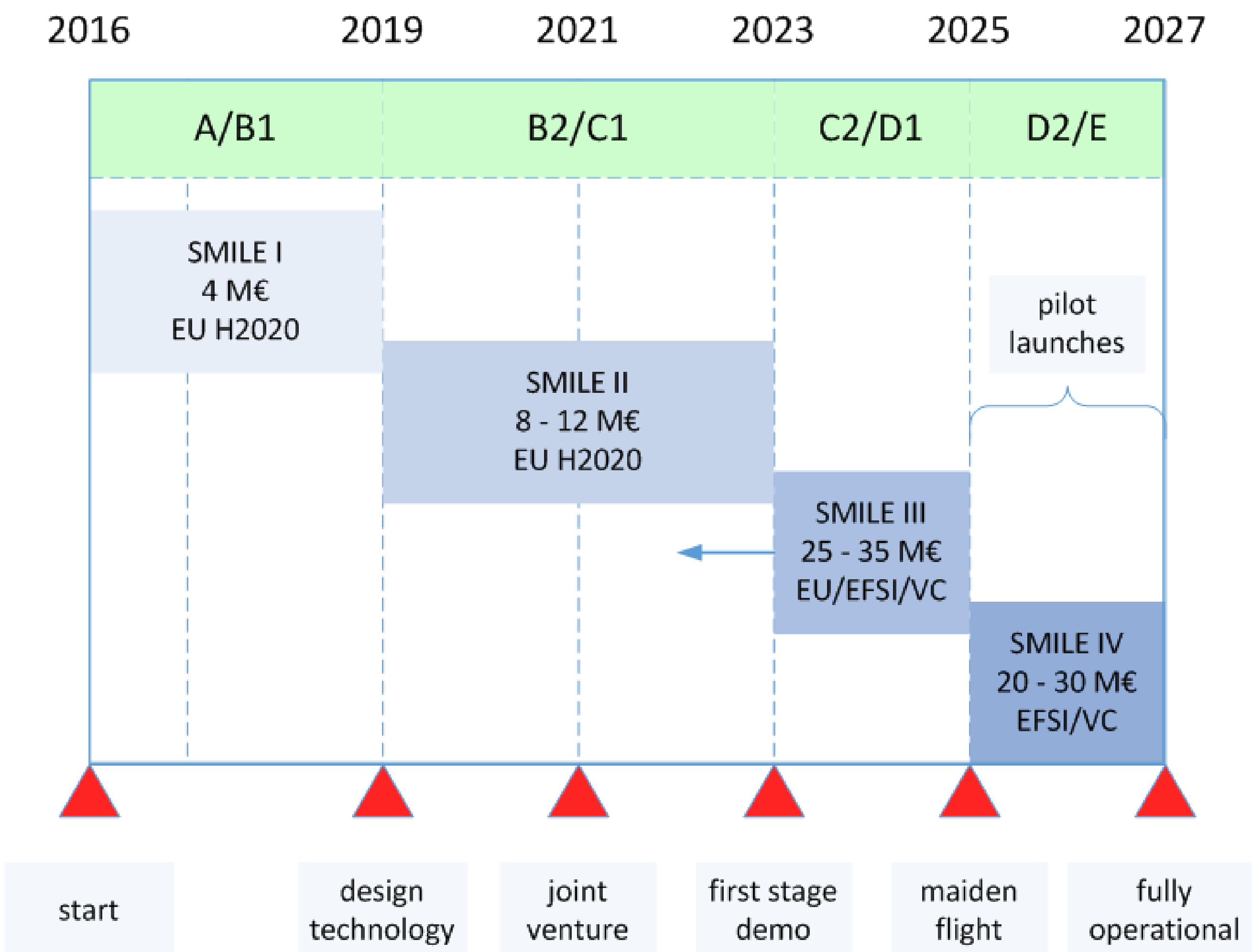
Business Development



Note: timeline subject to change

Funding options include:

- public (EU/ESA/national)
- private (venture capitalists)
- loans (banks, EIB)

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