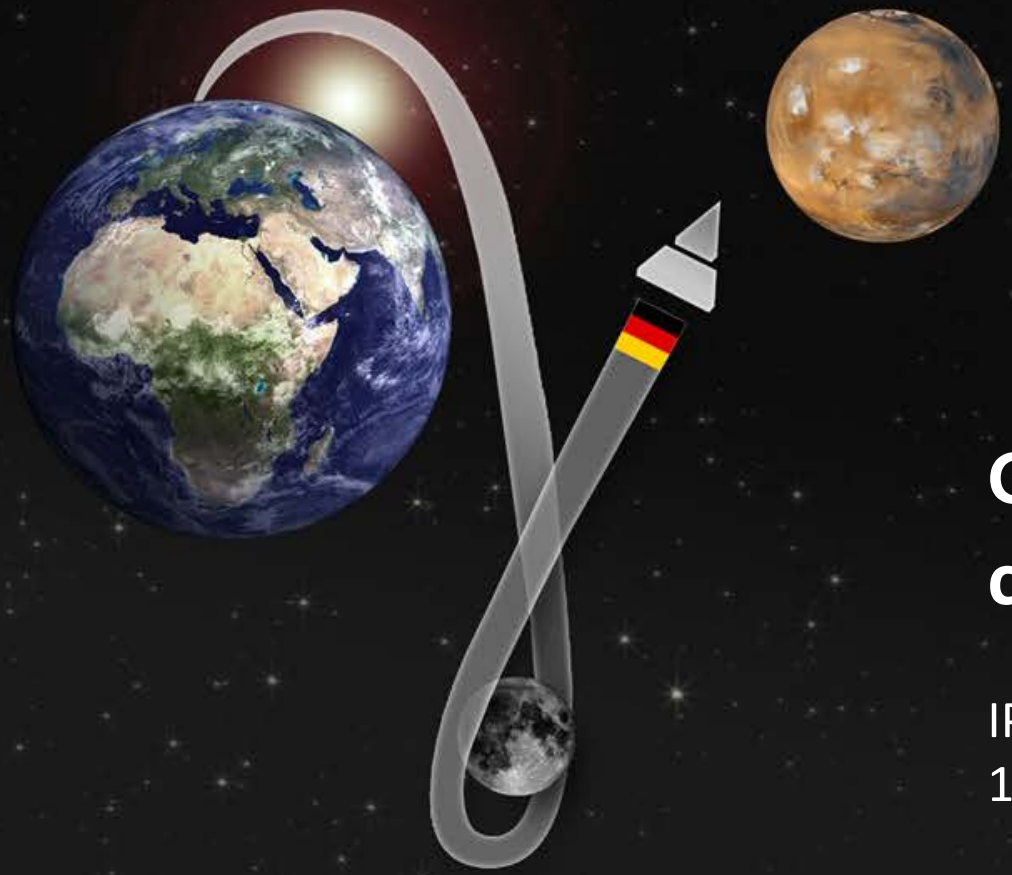

GAMMa - A modular ascender concept for sample return missions

IPPW 15, Boulder, Colorado, USA
14th June 2018

Bundesministerium für Wirtschaft und Energie

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DEFENCE AND SPACE

R. Buchwald, F. Ebert, O. Angerer

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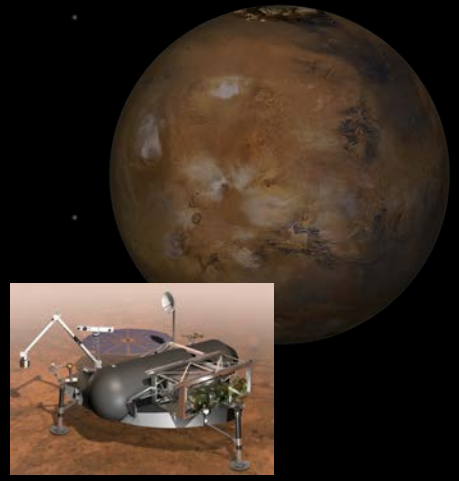
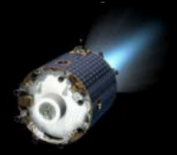


Mars Sample Return (MSR)

Lunar Polar Sample Return (LPSR)

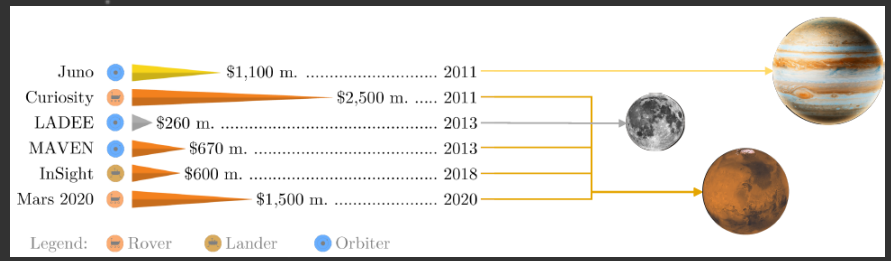
Deep Space Gateway (DSG / LOP-G)



Human assisted Sample Return (HERACLES)

Motivation behind GAMMa

- Cornerstone missions are expensive “one-offs”;
  → 40% cost reduction could be achieved by multi use of design



- Cornerstone missions are planned to be cooperative
  → programmatic independence by modular design

- Skunk works approach can reduce development time
  → Cost and risk reduction by in-flight qualification

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Gemeinsamkeiten von Aufstiegsstufen für Mond und Mars

Modular Ascender Family

- Lunar Robotic Ascender
- Lunar Human Assisted Ascender with Kickstage
- Mars Robotic Ascender with Kickstage

Video

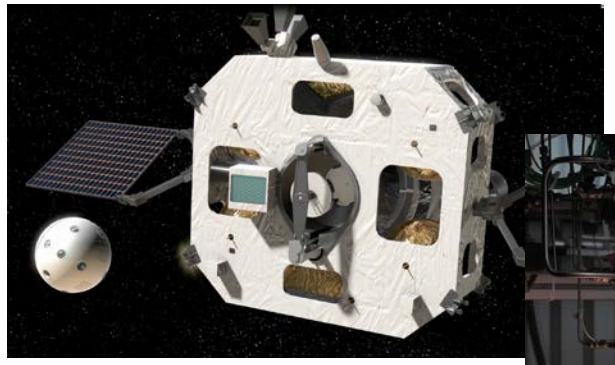
Benefit Analysis - Top Level Risks

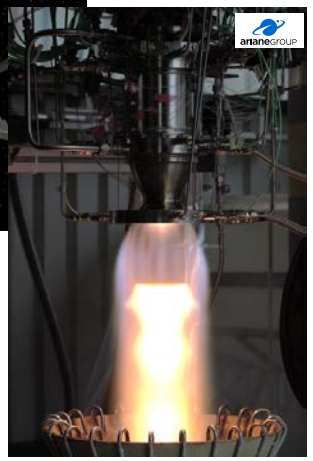
1. Rendezvous and capture of an orbiting sample
   - Free flying capture has low TRL
   - Retrial options for this mission critical element are limited

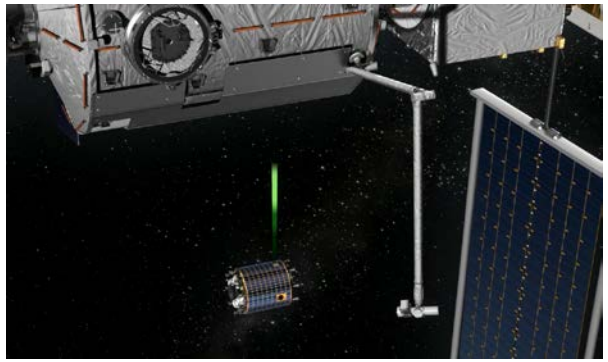
2. Rendezvous and berthing with a man-tended habitat
   - HERACLES robotic demonstrator will serve as demonstrator for a human architecture
   - The demonstrator will rendezvous and berth with the DSG

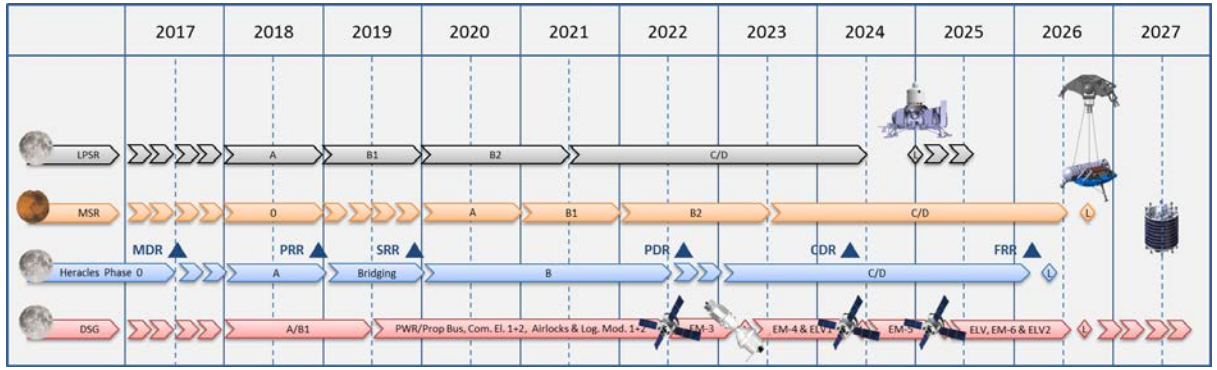
3. Availability and maturity of main engine
   - No flight proven MSR or HERACLES engine is existing today
   - BERTA engine demonstrator could be scaled and qualified but is currently not man-rated
   - Solid rocket options require further analyses but cannot be scaled easily to human architecture

4. Programmatic schedule of cooperative projects
   - Plans for MSR, LPSR and HERACLES are all in cooperation with international partners and schedules are likely to shift









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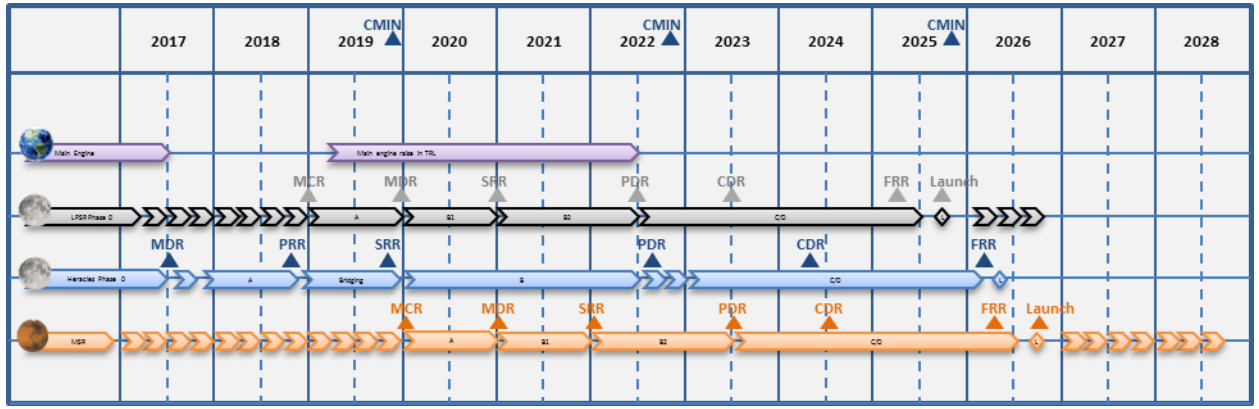
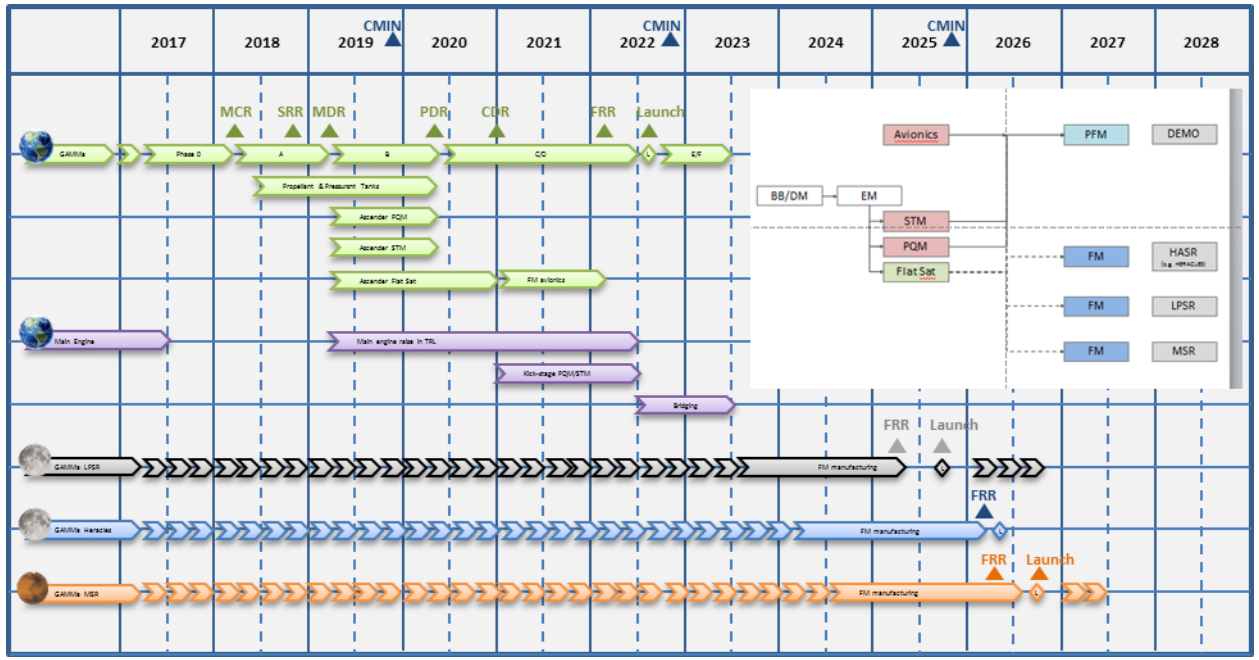
Benefit Analysis - Development Plan and Master Schedule

1. Classical development approach
   - HERACLES
     - 7 years development time, QM/FM approach
     - Pre-development for engine and TRL<6 items
   - LPSR
     - 5.5 years development time
     - PFM approach
   - MSR
     - 7 years development time
     - PFM approach
     - Pre-development for engine and TRL<6 items

2. GAMMa development approach
   - GAMMa Ascender Demonstrator
     - 3-4 years development time for ascender, PFM approach
     - Pre-development for propellant and pressurant tanks
   - HERACLES, LPSR, MSR
     - 2 years FM re-built
     - Pre-development for main engine and kick-stage tanks





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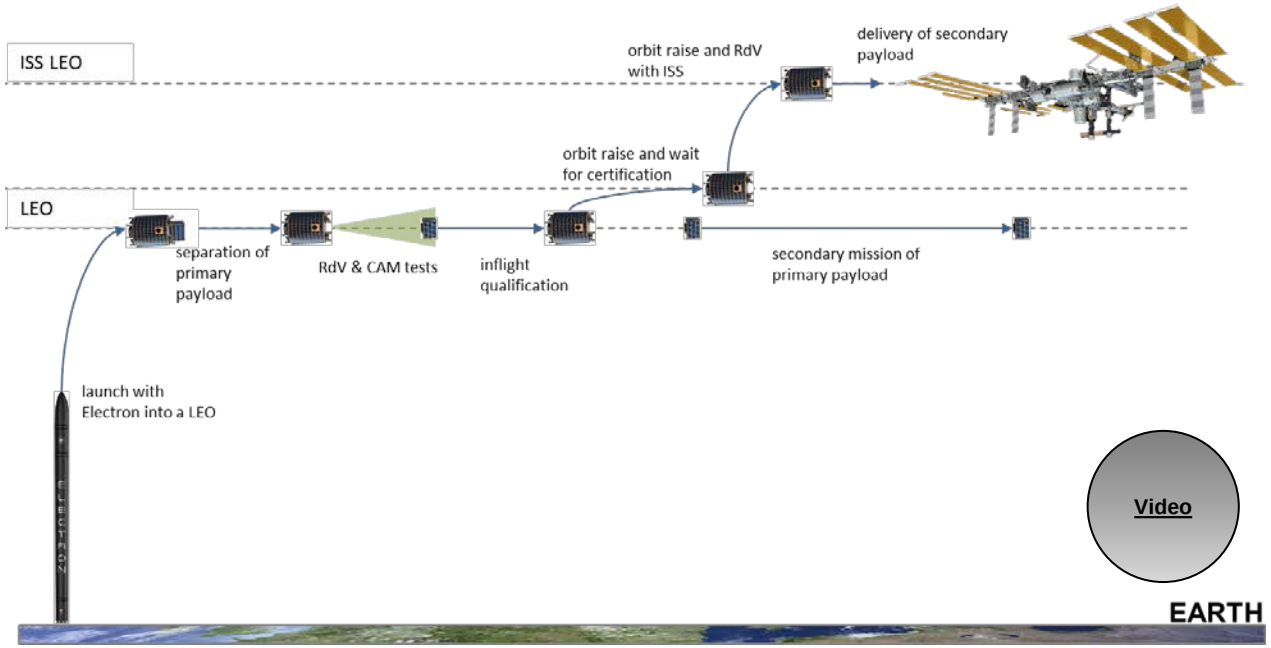
Benefit Analysis – Full-scale Technology Demonstration

Demonstration objectives:

- Early hardware demonstration and in-flight qualification of ascender system to achieve a “real” TRL increase
- Qualification and certification of rendezvous and proximity operation related functions in real operational environment

Primary mission scenario:

- Launch on low cost micro launcher (e.g. ELECTRON) into LEO
- Deploy passenger payload
- Perform rendezvous experiments
  - on-board rendezvous sensors on ascender and target marker on passenger payload
  - inter-satellite link between ascender and payload
- Demonstrate safe modes, hold points, and CAM



Secondary mission scenario:

- Science mission of passenger payload
- Rendezvous and berthing demonstration at ISS + disposal
- Optional delivery and hand over of high risk payload
- Optional science mission

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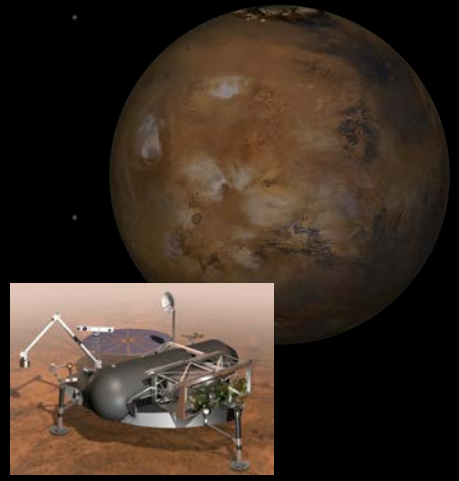

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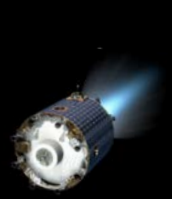

Human assisted Sample Return (HERACLES)

Deep Space Gateway (DSG / LOP-G)

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Gemeinsamkeiten von Aufstiegsstufen für Mond und Mars

GAMMa modular ascender family

- Single stage to orbit for LPSR
- LPSR ascender + kick-stage to adapt to MSR mission profile
- MSR ascender + body kit to account for human assisted sample return architecture (HERACLES)

→ Programmatic independence and reduced cost and risk by multi-mission layout and technology transfer

→ In-flight qualification opportunity on micro launcher


Gemeinsamkeiten von Aufstiegsstufen für Mond und Mars
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