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# **IAA SG3.28**

## **Strategy of Large-scale and Low-cost Access to Space in Future**

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**Sep. 2017**



# Introduction



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## **Goal:**

Identify the requirement of access to space and exploration payload in future, and required key technologies and strategy to meet this kind of requirement.



# Introduction



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**Sep.2016 The Study Started**

**Mar. 2017 The Study Group and Report Outline Finished**

**Sep.2017 The Preliminary Report Finished**

## **1. Introduction**

## **2. Demand and technology analysis of large-scale access to space in future**

- ✓ **Mission demand analysis of access to space (aiming at 2030, 2050)**
  - **low-earth orbit mission**
  - **Robotic and Human deep space missions**
  - **Construction of space infrastructure, such as, space solar power station**
  - **On-orbit service and maintenance**
  - **Space tourism**
- ✓ **Limitation analysis of current LV technologies for access to space**

- ✓ **Limitation analysis of current LV technologies for access to space**
  - Most launch vehicles carry on specific missions. Some capabilities of launch vehicles are not fully used.
  - The period of launch service for a general ELV is more than 2 weeks which is too long for consecutive missions. Moreover, the number of people involved in the launch service is also large.
  - An ELV is always designed for a distinctive orbit. The adaptability for multi-mission needs to be increased.
  - The launch service price is expensive.

## ✓ **Method for low-cost access to space**

### ➤ **Launch vehicles**

- Low-cost design of expendable launch vehicles
  - (1) Low-cost electrical system design
  - (2) Low-cost structure design technology
  - (3) Low-cost propulsion system design technology
  - (4) New launching technology
  - (5) Others
- Reusable design
  - (1) Reusable Space Transportation Systems Based on ELVs
  - (2) Lifting-Body Configuration Launch Vehicles
    - » Rocket Powered Reusable Launch Vehicles
    - » Combined-Cycle Powered Reusable Launch Vehicles

### ➤ **Interface standardization**

### ➤ **Other New concepts**

- Depot, Electromagnetic propulsion launch vehicle, Space Elevator

## 3. Key technologies of large-scale and low-cost access to space

- ✓ Launch vehicles
  - Low-cost design of expendable vehicles
    - The low cost design technology of launch vehicle configuration
      - » (1) Low cost hybrid launch vehicle configuration
      - » (2) Low cost serialized LV configuration and the modular design technology
    - The high reliable electrical system integration design in launch vehicle
      - » (1) Integration power supply and distribution technology
      - » (2) Modular design technology in electrical system
    - The high reliable electrical products and test technology based on COTS
      - » (1) device procurement and screening control
      - » (2) heat-electromechanical design in application environment
      - » (3) COST device error detection and tolerance
    - The improvement of active serviced launch vehicle
      - » (1) launch vehicle combined lots production;
      - » (2) components commercialized design;
      - » (3) advanced techniques application (3d print for example) and long-range fast test and launch technology

## 3. Key technologies of large-scale and low-cost access to space

### ✓ Launch vehicles

- Low-cost design of expendable vehicles
- Reusable design
  - (1) Rocket Powered Reusable Launch Vehicles
    - » Systems overall design and optimization technology
    - » Aerodynamic configuration and characteristics design technology
    - » Thermal protection technology
    - » High precision in-orbit and re-entry integration GNC technology
    - » Light-weight structure technology
  - (2) Combined-Cycle Powered Reusable Launch Vehicles
    - » Wide-scope vehicle body and propulsion integrated and strong coupling design technology
    - » Combined-cycle engine powered adjustable air intake and exhaust technology
    - » High flexibility and multi-model engine combustion organization technology
    - » Wide speed range inner and outer flow integrated configuration design technology
    - » Large-scale and light-weight lifting body vehicle aerothermo-elasticity technology
    - » Advanced guidance technology with strong coupling among propulsion, aerodynamic and flight path
    - » Vehicle and propulsion integrated control technology



## 3. Key technologies of large-scale and low-cost access to space

- **New concepts**
  - **Depot**
    - The cryogenic propellant in-space storage
    - In-space propellant transfer
    - Cryogenic tank pressure control
    - Assembly attitude control for propellant refueling
    - Liquid sloshing and large structure coupled dynamic modeling and control
    - Power supply and management
  - **Electro-magnetic launch vehicle**
    - analysis of ground effect of electromagnetic propulsion launch vehicle
    - accurate takeoff control technologies
    - high power, high capacity [pulse power supply](#) technologies
    - high speed, high power linear motor technologies
    - electromagnetic compatibility technologies
    - The optimization design of Electromagnetic propulsion launch vehicle's aerodynamic shape

## **3. Key technologies of large-scale and low-cost access to space**

- **Space Elevator**

- Optimization design technique for the overall parameters of Space Elevator system
- Dynamic design and analysis technology of Space elevator system
- Space task mode and orbit design technology based on Space Elevator system
- Design technology of Space Elevator tether material
- Space Elevator tether construction technology
- Control technology of Space Elevator tether expansion
- Optimization design technique of Space Elevator climber's overall scheme
- Optimization design technique of Space Elevator energy system scheme

## **4.Task mode and solution based on large-scale and low-cost access to space**

- Reusable
- Piggyback launch
- Launch by SLV
- Network launch

## **5.Operation management and international cooperation mode in future**

- **Value research on large-scale and low-cost entering space in the future**
  - Research on commercial market value
  - Research on non-commercial market value
- **Mode research on large-scale and low-cost entering space in the future**
  - Operation mode
  - Business operation mode
  - Investment and financing management
  - Risk assessment
- **International cooperation development and innovation in the future**
  - International cooperation status
  - International cooperation development in the future

## **6. Relevant laws and policies**

- The problem of space debris
  - Current situation of space debris
  - Analyze the source of space debris
  - The evolution of space debris environment
- Suggestion of Disposal measurements
  - Current situation of international space debris management
  - Requirements of launch vehicle based on space debris mitigation
  - Requirements of satellite based on space debris mitigation

## **7. Conclusions and suggestions**



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**Thanks!**