



**中国航天标准化研究所**

China Astronautics Standards Institute

The background of the slide is a composite image. On the left, a rocket is shown launching with a large plume of white smoke. In the center, the Great Wall of China is depicted winding across a landscape. On the right, a satellite is shown in orbit above the Earth's surface, with a bright light source behind it.

# SAFETY ASSRANCE OF MANNED SPACE PROGRAM OF CHINA

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2008-11-5

**China Astronautics Standards Institute**

# PRESENTATION OUTLINE

**1 INTRODUCTION**

**2 CHARACTERISTICS OF SAFETY ASSURANCE**

**3 SAFETY ENGINEERING ASPECTS**

**4 CONCLUSION**



# INTRODUCTION

★ Astronaut safety issue, the No.1 issue for manned space program

★ In history, 18 killed flights, 4 or more killed ground tests

★ Spaceship, the world and living environment and a carrier to return

★ Safety, a design and

“挑战者”号失事 (1986.1)



“挑战者”号凌空爆炸



“挑战者”号上7名遇难宇航员

“哥伦比亚”号失事 (2003.2)



“哥伦比亚”号失事，碎片坠落



“哥伦比亚”号遇难的7名宇航员



# INTRODUCTION



SZ-7: 25 -28 Sep.2008

SZ-6: 12 - 17 Oct.2005

SZ-5: 15 -16 Oct.2003

SZ-4: 30 Dec - 5 Jan. 2003

SZ-3: 25 Mar - 1 Apr.2002

SZ-2: 10 - 17 Jan.2001

SZ-1: 20 - 21 Nov.1999





## China's approach

- Design the safety into products
- Analyses, tests, verification
- Effective management and quality control
- Considerations of Chinese industry infrastructure
- Astronaut safety issue, the No.1 issue for manned space program
- Lessons learned or experiences inherited
- 4 unmanned vehicles before 3 manned vehicles



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**2 CHARACTERISTICS OF SAFETY ASSURANCE**

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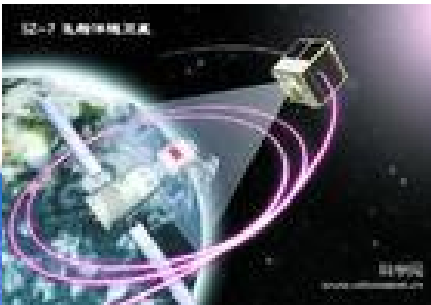
**4 CONCLUSION**





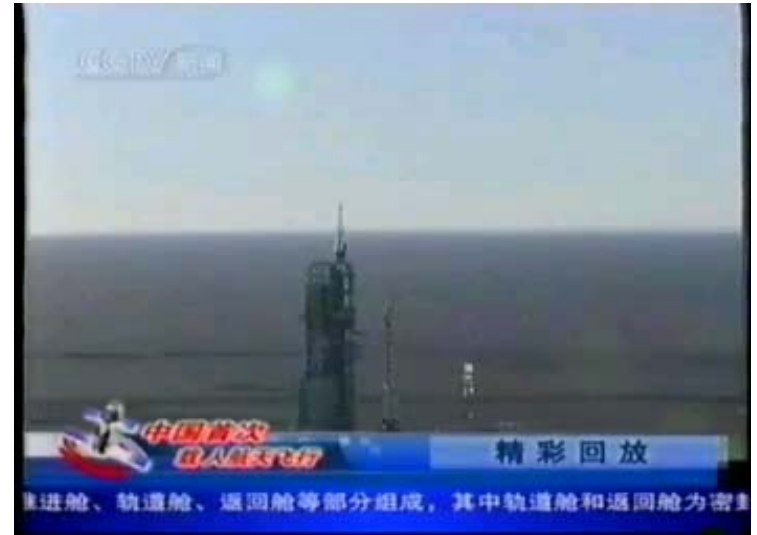
## 2.1 Incremental design enhancement

- SZ-1: overall scheme
- SZ-2:
  - Fault detection
  - Emergency evacuation and escaping
- SZ-3: re-entry
- SZ-4:
  - Space-ground communications
  - Interfaces of automatic-manual commands



## ➤ SZ-5:

- 1 man 1 day flight
- First Chinese in space



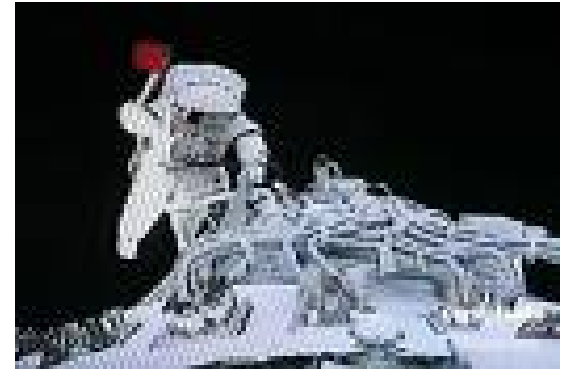
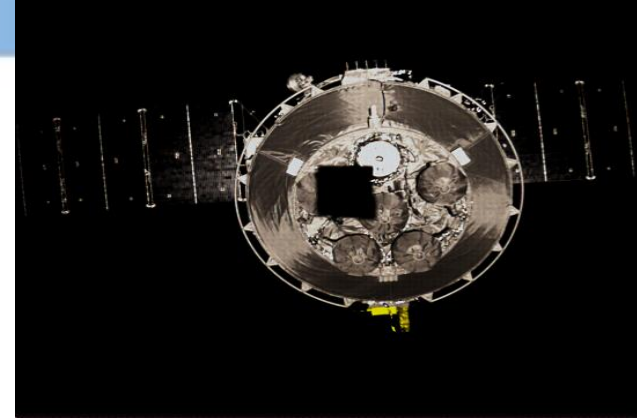
## ➤ SZ-6:

- 2 men, multiple days
- Man-machine compatibility
- Comfortableness



## ➤ SZ-7:

- 3 people, multiple days
- Off-the-vehicle operation
- Accompanying micro satellites



# CHARACTERISTICS OF SAFETY ASSURANCE

- Strict configuration control played a dominant role to assure flight verified design measures are maintained and inherited.
- Safety design guidelines are documented and implemented in later vehicles and safety related data are accumulated, facilitating more accurate safety assessment.





## 2.2 Safety verification

- Examine whether the spaceship meets the prescribed safety criteria
- Engineering tests
- Probabilistic assessments



2008-11-5





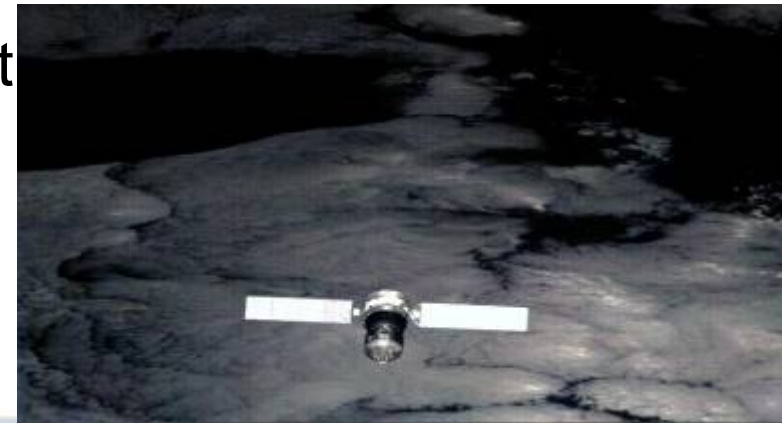
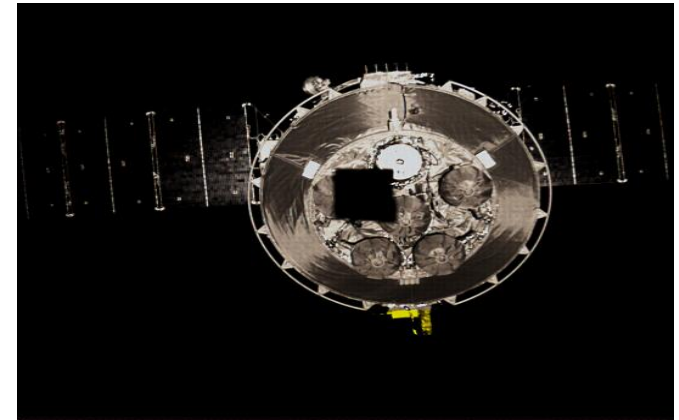
## 2.3 Safety design criteria and standardized practices



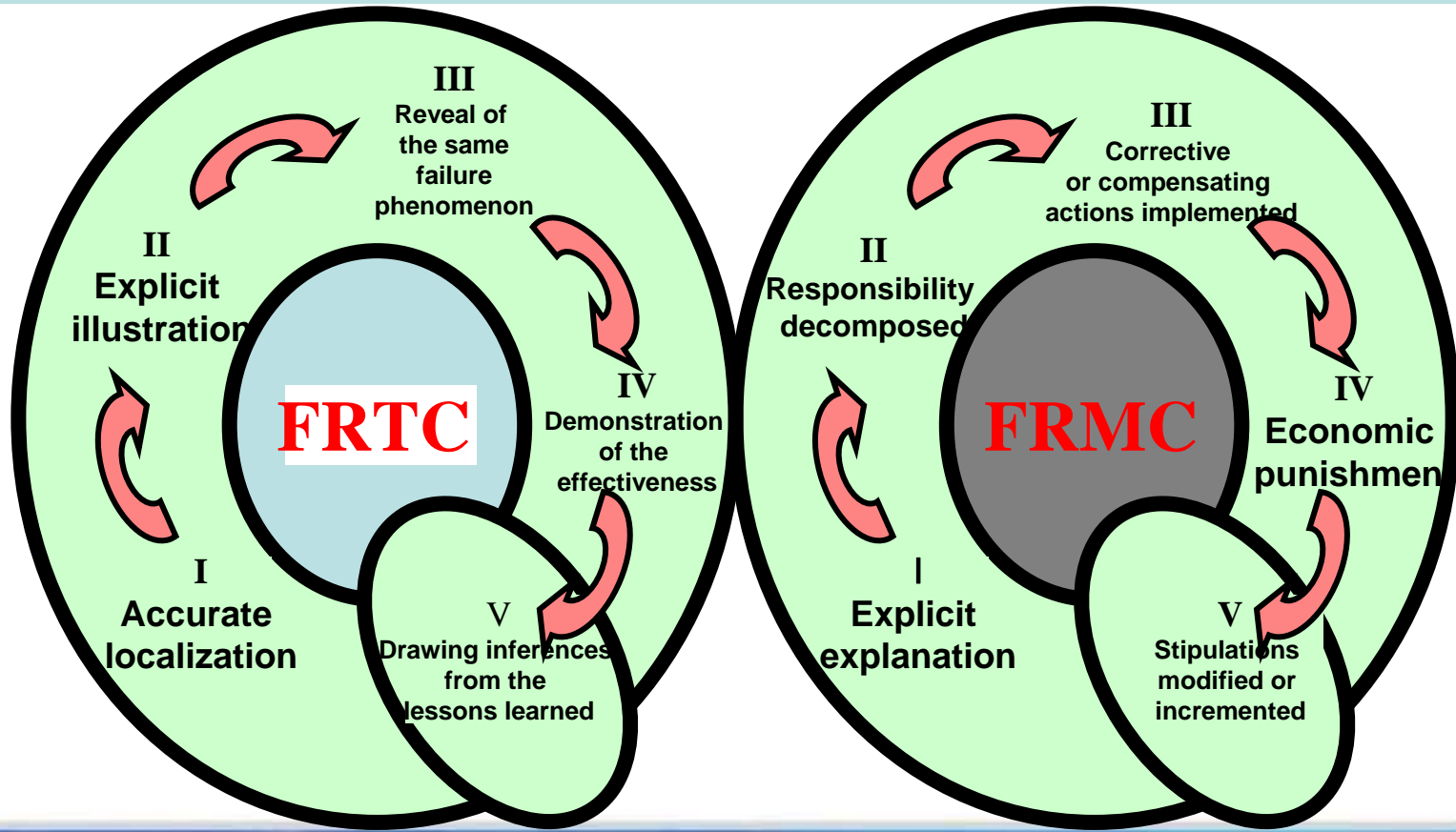


## 2.4 Special issues of safety design

- new or modified designs
- For SZ-7 spaceship
  - independent isolation cabin
  - Extra-vehicular space suit
  - circling micro-satellite



## 2.5 Strict implementation of Double Five Rules of Close (DFRC)



- **Double Five Rules of Close (DFRC)**
  - Closes of quality concerns
    - Complete elimination of quality concerns (failures, faults, defects, abnormalities, etc.)
    - Whenever they occur
    - By means of a series of activities including analysis of causes and mechanisms, corrective and preventing measures
    - Aiming at preventing the similar problems from repetitive occurring

- **Five Rules of Technical Close (FRTC)**
  - **Accurate localization** of the failure causes, distinguishing the inherent cause from dependent failures
  - **Explicit illustration** of failure mechanisms
  - **Reveal of the same failure phenomenon** under recognized failure causes and mechanisms (through revealing test or simulation)
  - **Demonstration of the effectiveness** of corrective actions (through demonstration test or simulation)
  - **Drawing inferences from the lessons learned** to more general cases used for other similar occasions or other systems within or beyond the project

- **Five Rules of Managerial Close (FRMC)**
  - **Explicit explanation** of the developing and propagating of failures from the administrative point of view
  - **Responsibility decomposed** down to every administrative level
  - **Corrective or compensating actions implemented** for the occurred failures
  - **Economic punishment** for the responsible bodies and personnel
  - **Stipulations modified or incremented** to avoid the repetitive failures

## 2.6 The most important design and analysis tasks

1+8+2

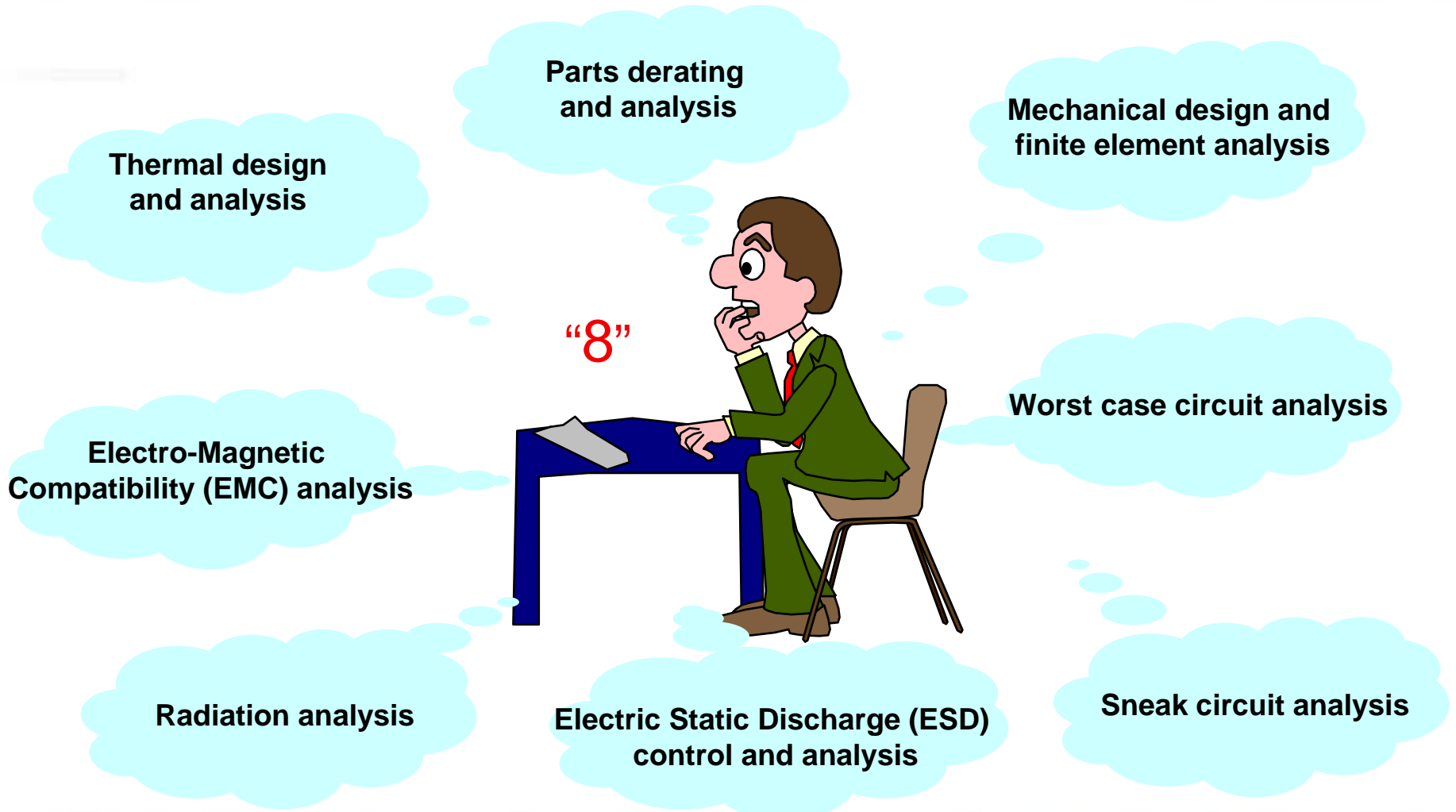
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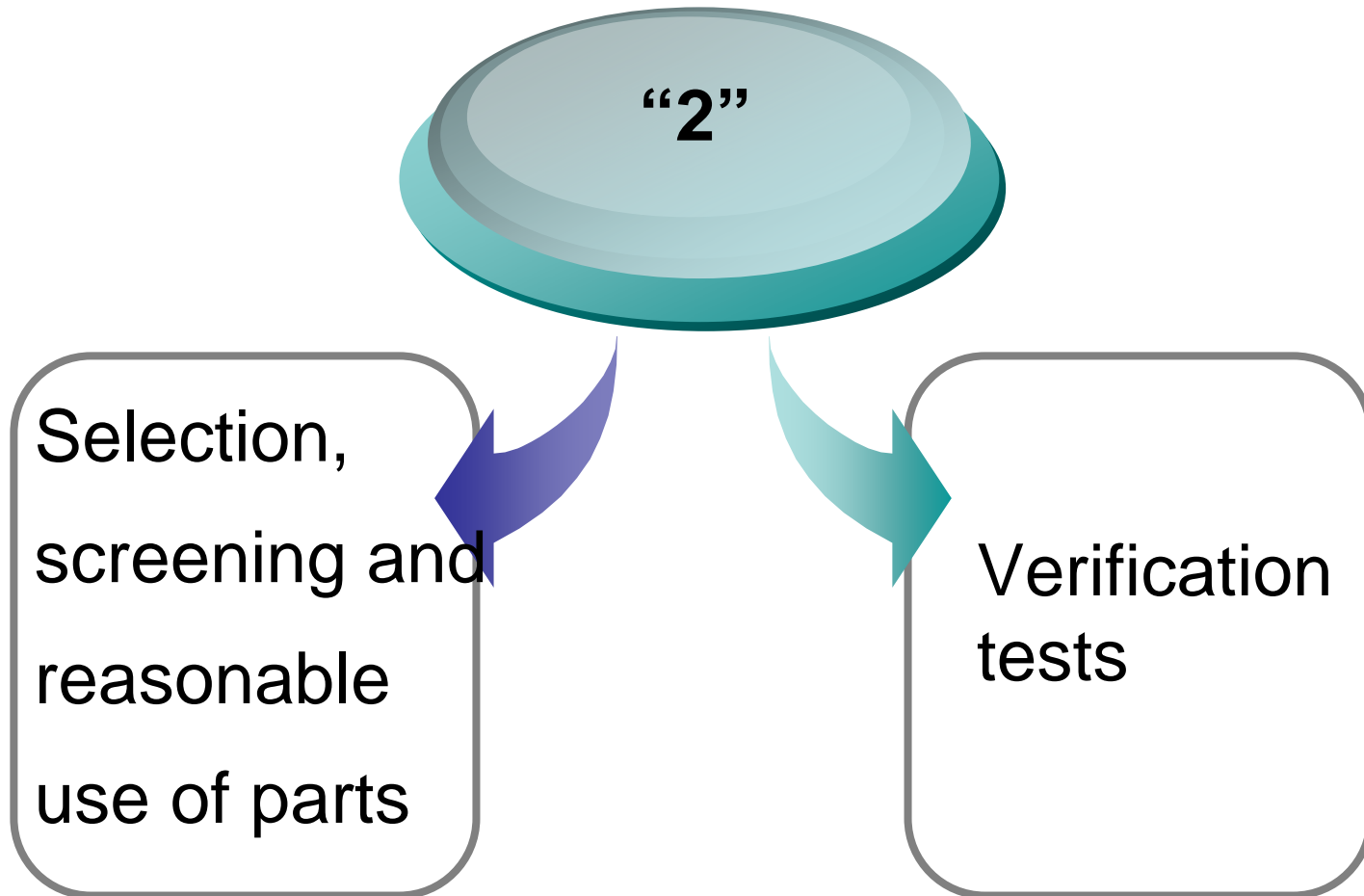
- How could things go wrong ?
- Where are the biggest risks ?



# CHARACTERISTICS OF SAFETY ASSURANCE



# CHARACTERISTICS OF SAFETY ASSURANCE





## 2.7 Emergency plans

- covering the whole mission profile, from pre-flight tests, launch, ascent, orbiting, de-orbiting to re-entry and landing
- For SZ-7
  - 200+ emergency plans
  - 1000+ pages
  - 228 system level failure modes (70 new versus SZ-6)
  - 75 accommodation plans for 18 emergency re-entry modes



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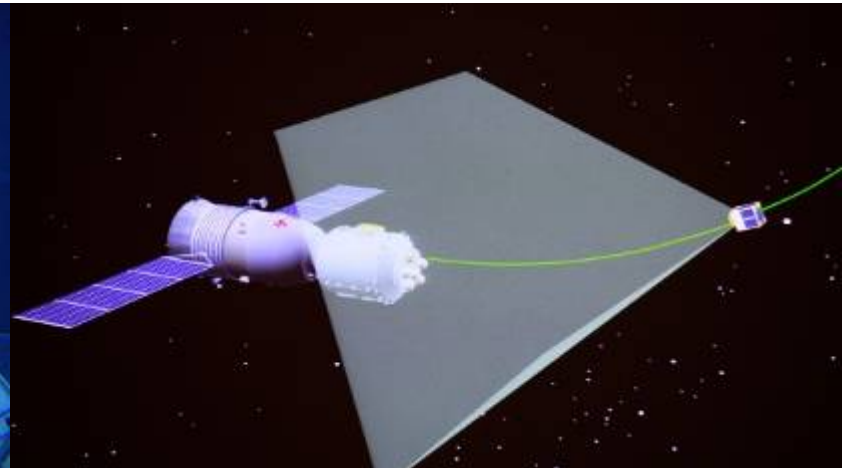
**4 CONCLUSION**





## 3.1 Safety assurance program

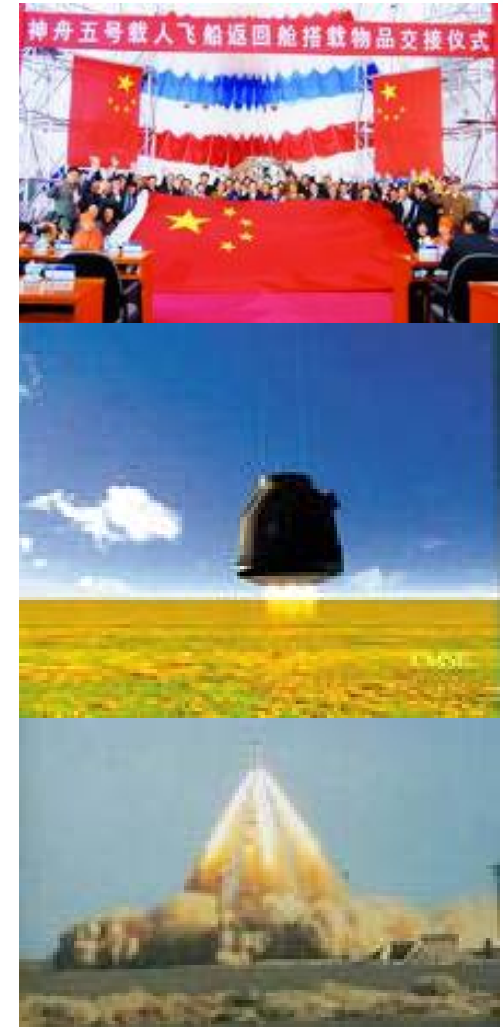
- “Safety Assurance Program for Shenzhou spaceships”
- Slightly modified from SZ-5 to SZ-7





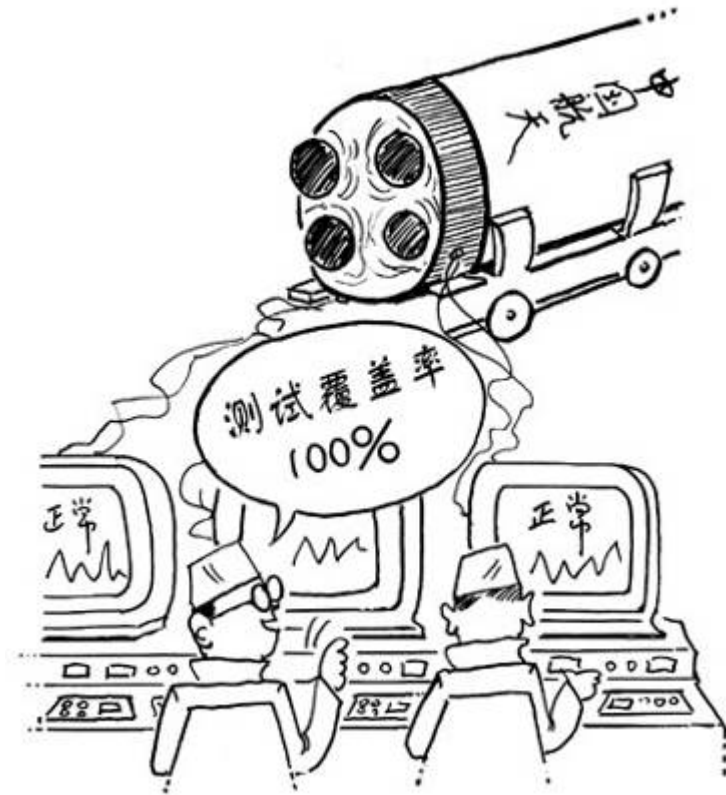
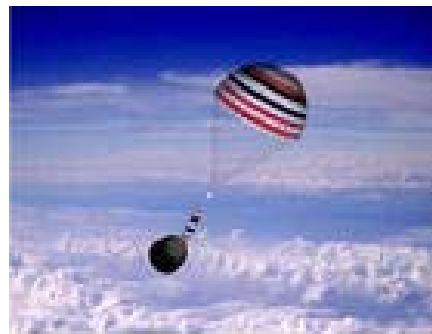
## 3.2 Safety requirements

- Quantitative: given by probabilistic safety indexes, e.g., **0.997** for astronaut safety.
- qualitative requirements



## ➤ For SZ-7 :

- accurate orbiting
- stable orbital operations
- successful off-the-vehicle operation
- safe and healthy return





## 3.3 Systematic safety analyses

**(1) Identification of general sense hazards**

**(2) Identification of hazards due to system malfunctions**

**(3) Analysis of the safety influence of configuration changes**





## 3.3 Systematic safety analyses

**(4) Identification and control of safety critical items**

**(5) Implementation of safety design requirements  
Control of residual hazards**

**(6) Special purpose safety tests**



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# CONCLUSION

- ✦ Seeking any possible opportunity to improve safety
- ✦ Effective and incremental enhancements
- ✦ Special purpose safety studies and tests
- ✦ Comprehensive safety analyses
- ✦ Incisive safety measures and emergency plans



Thanks for Attention

