

History of the Water Mist Project and CSM's involvement: Fighting Fires in Space with Water Mist



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Apollo 1

January 27, 1967

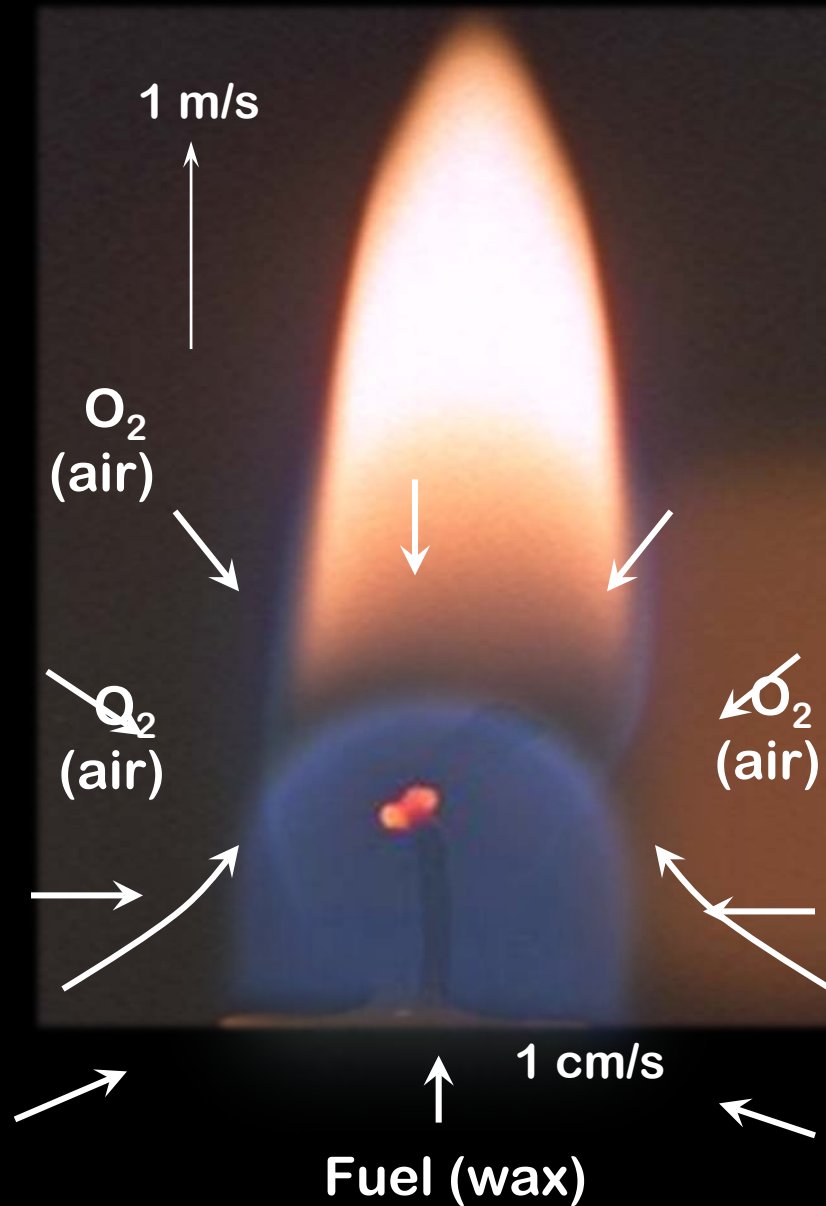


Lessons learned:

- * Switch from 100% oxygen to air**
- * Materials flammability**

1g (normal gravity)

μg (Weightlessness)



Feb 27, 1997

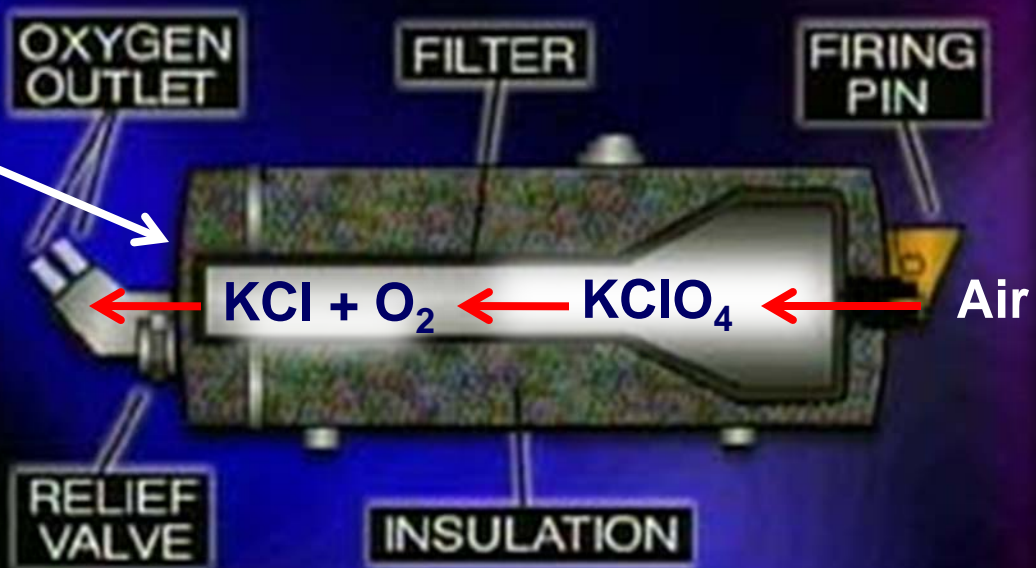


MIR
Space Station

Oxygen candle



OXYGEN GENERATOR





**Jerry Linenger
(US astronaut)**

Fire suppression in spacecraft



Halon 1301
($\text{CF}_3 \text{ Br}$)

Chemical

Carbon
Dioxide
(CO_2)



Physical



Motivation

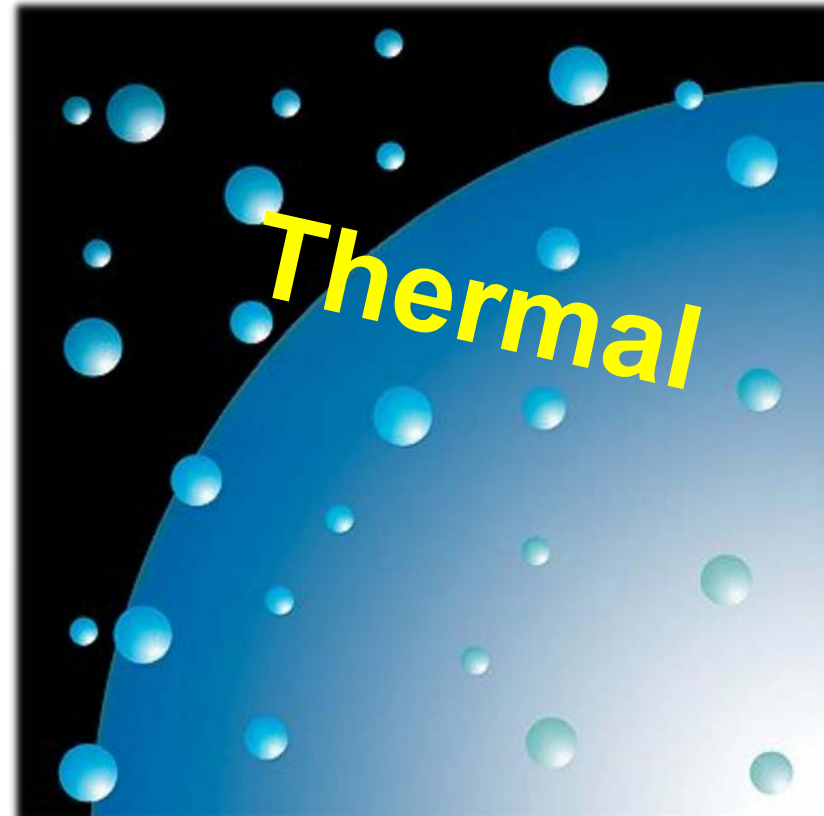


**CF₃Br
(Halon)**

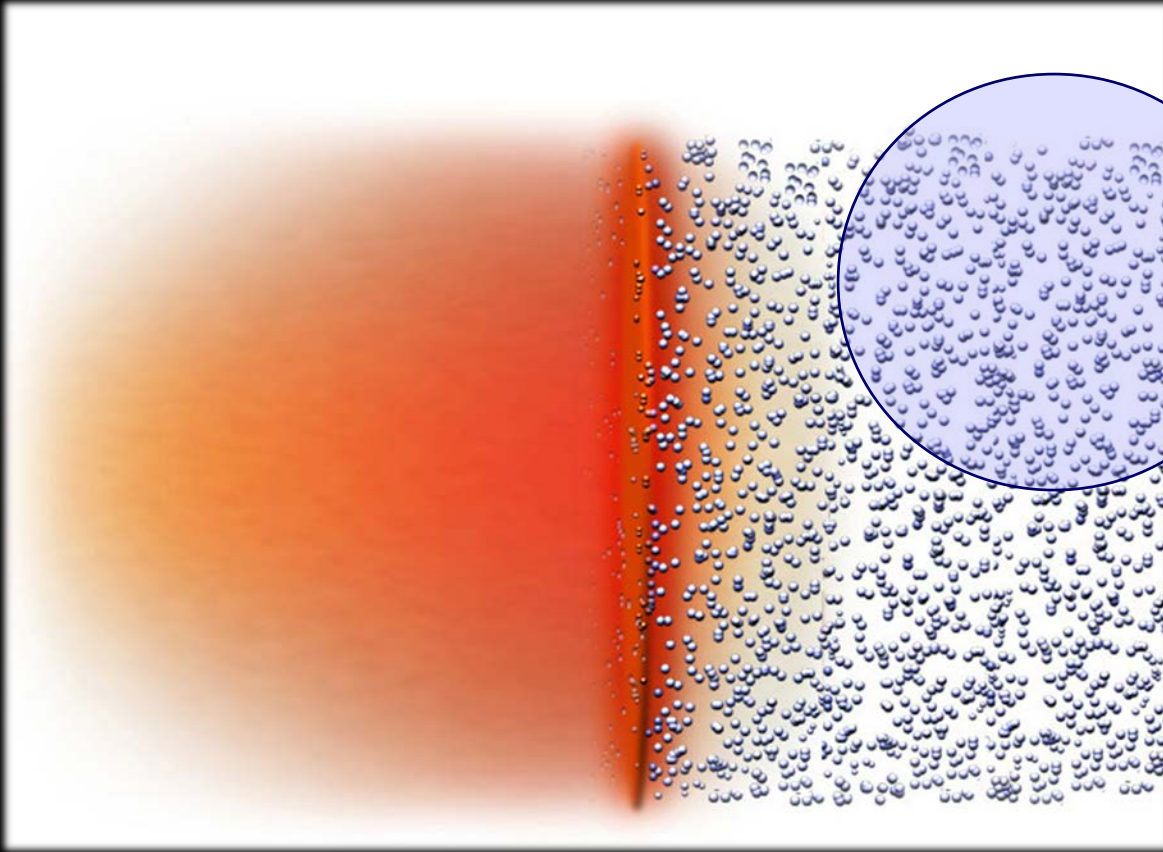


**Montreal
Protocol
(1994)**

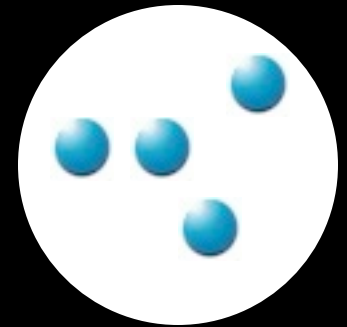
Water mist



Determine effect of:

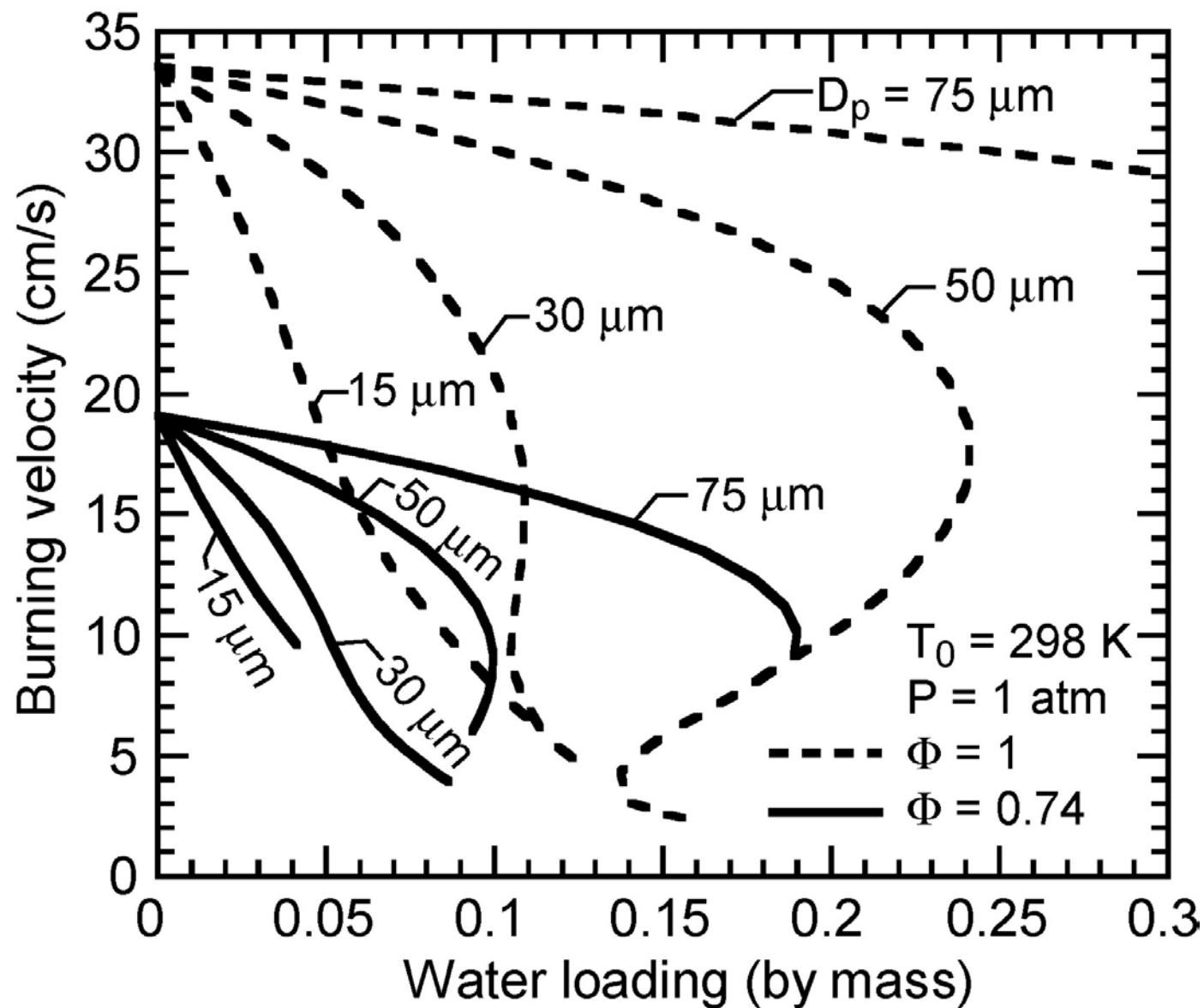


**Water
amount**

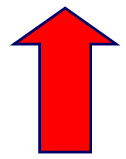


**Droplet
Size**

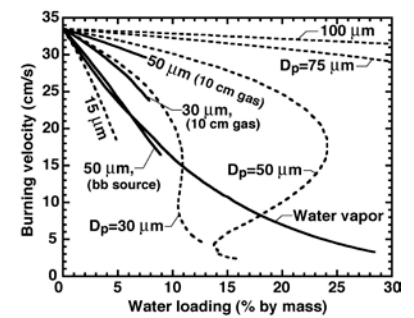
Numerical Model Results (CH₄-air)



GROUND TESTING

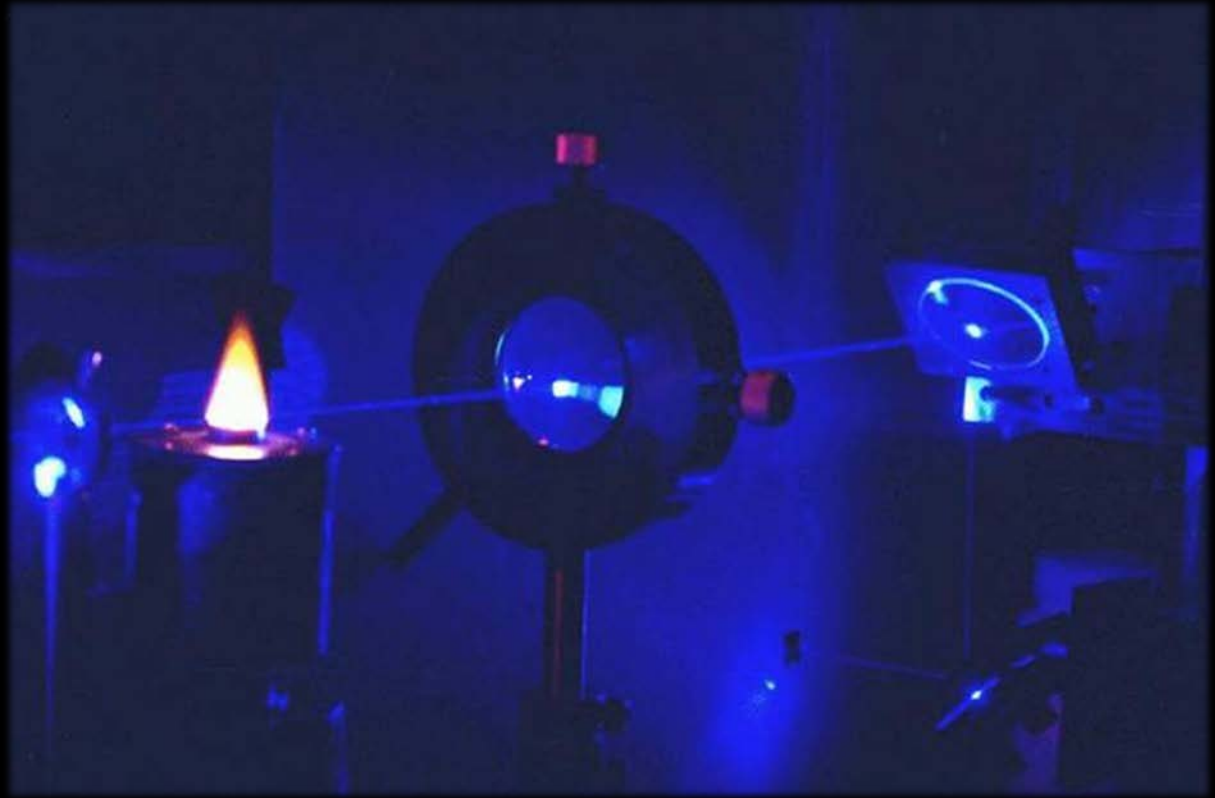


- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



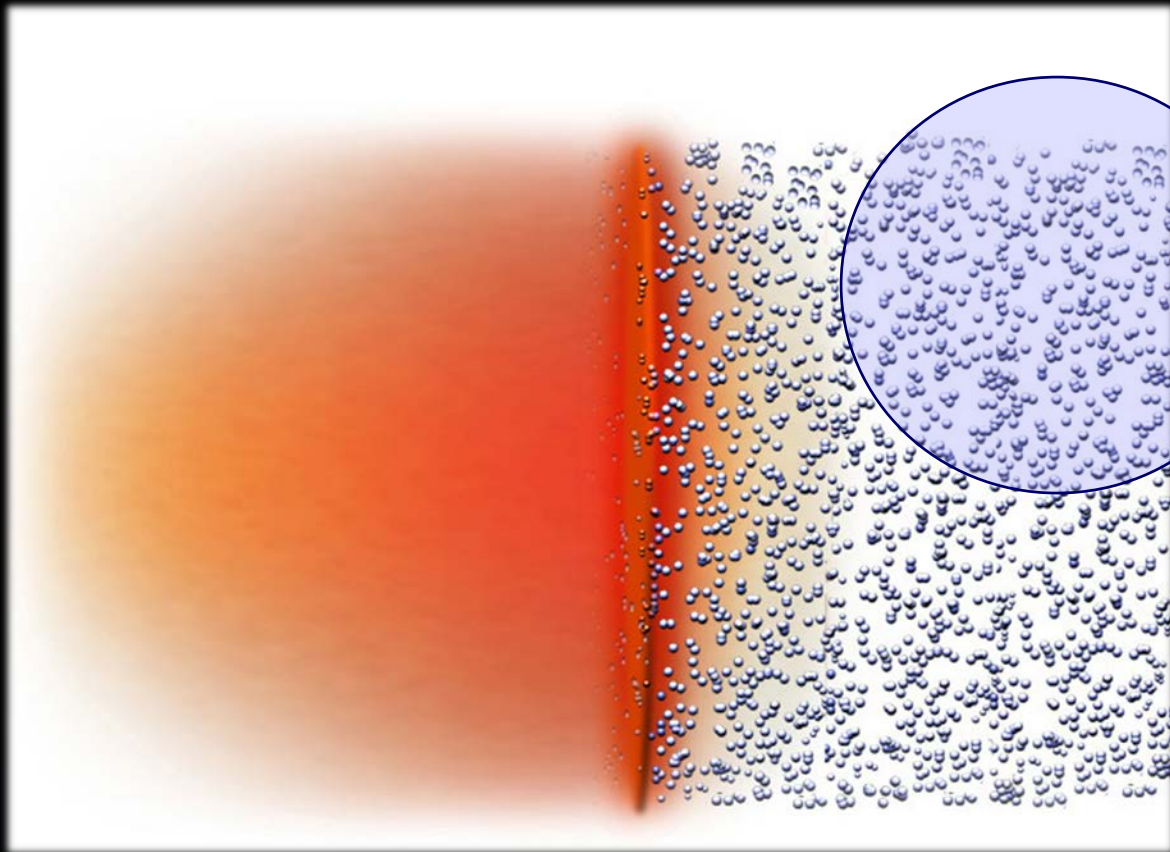
1997

GROUND TESTING

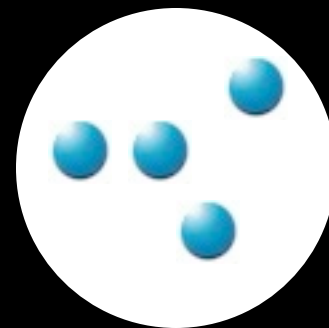


No gravity?

Determine effect of:

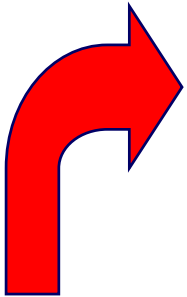


**Water
amount**

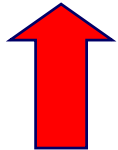


**Droplet
Size**

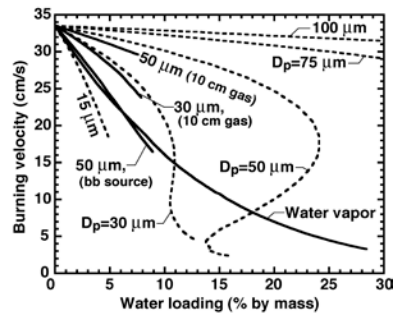
FREE FALL TESTS (GROUND FACILITIES)



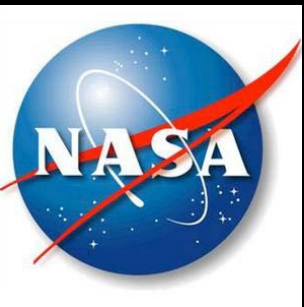
GROUND TESTING



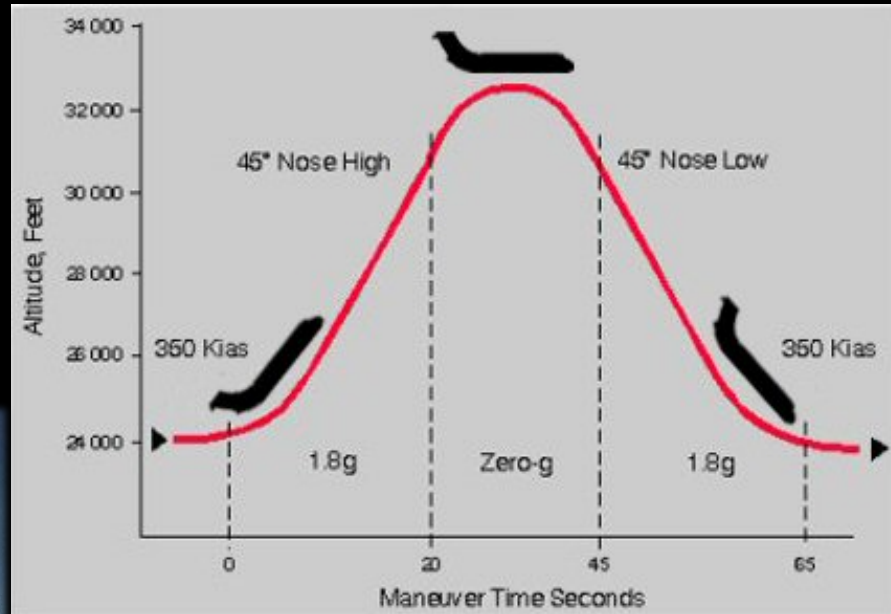
- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



Drop towers



Parabolic-trajectory airplane



$$x_f = (1/2) g t_f^2$$

For $t=25$ sec

Height ≈ 3125 m !



Free fall around Earth

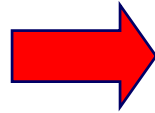
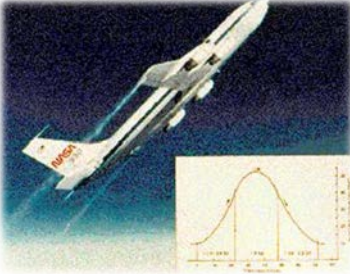
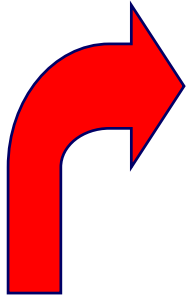
$t_f = \text{Days !}$



**LOW-GRAVITY
GROUND
FACILITIES**



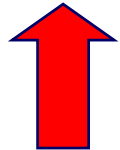
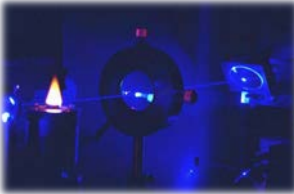
FLIGHT HARDWARE DESIGN AND DEVELOPMENT



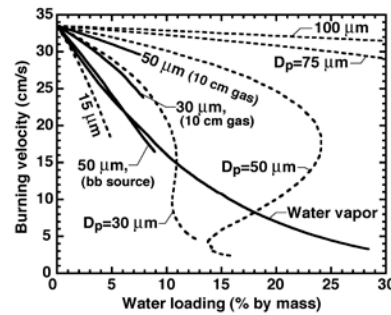
SPACECRAFT INTERFACE



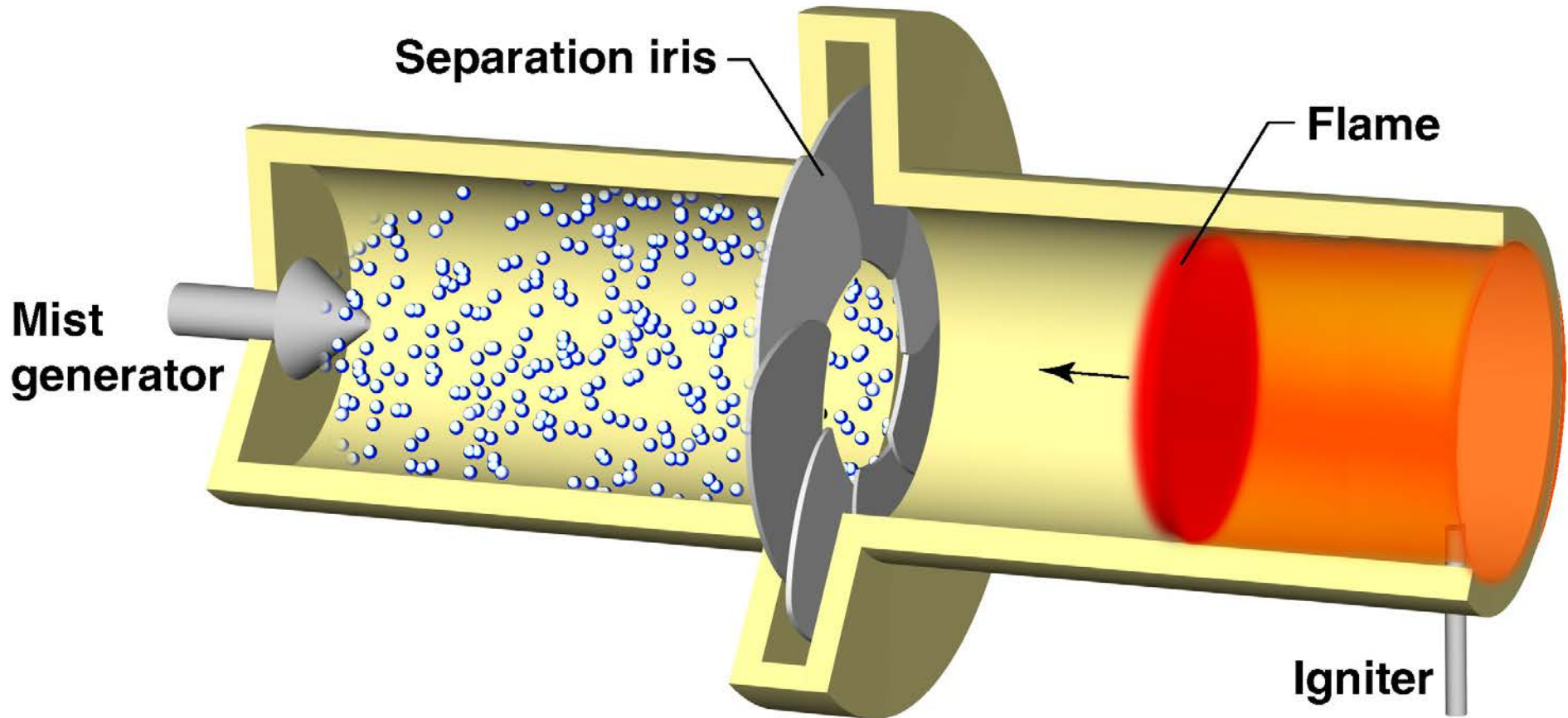
GROUND TESTING



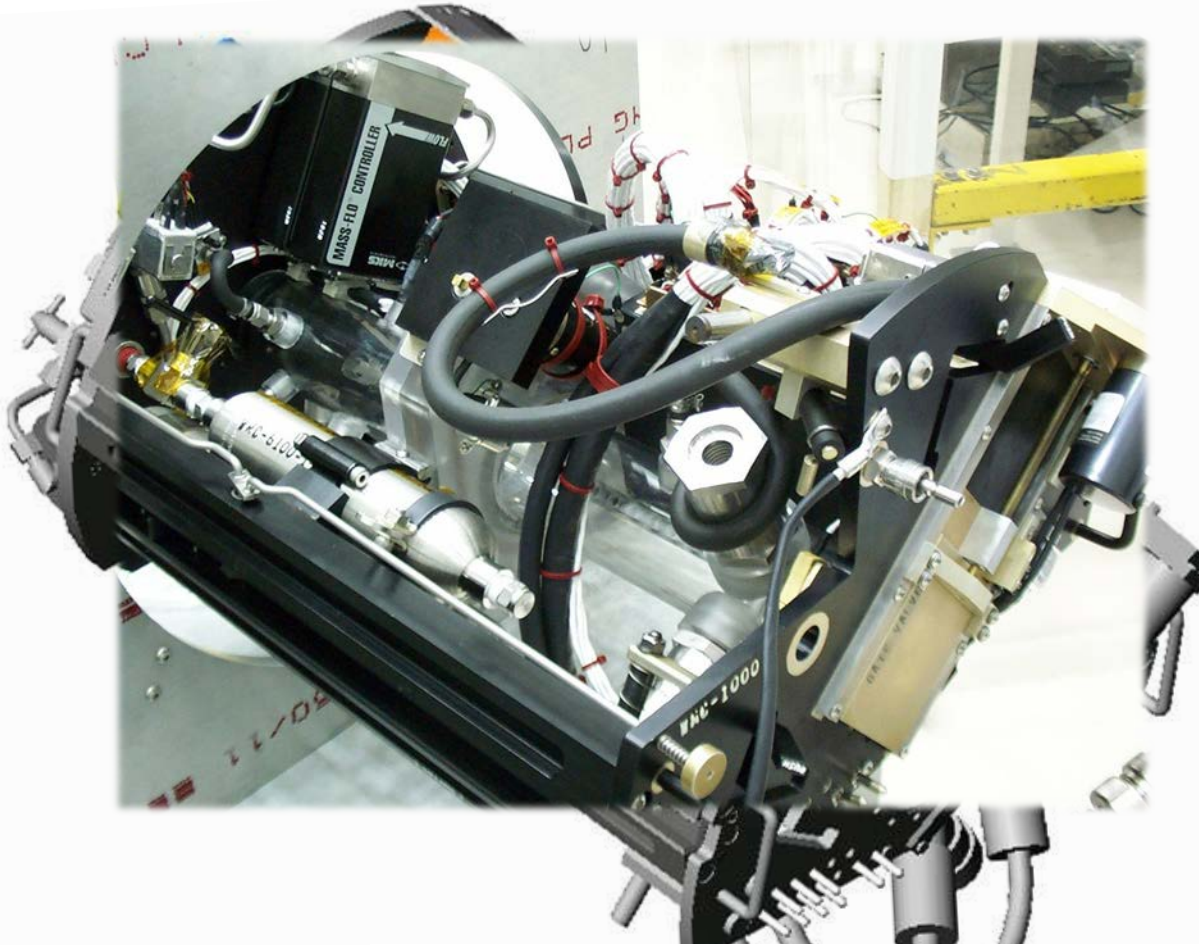
- OBJECTIVES**
- MODELING PREDICTIONS**
- REQUIREMENTS**



Design



Fabrication & Assembly



**Final Experimental
Mounting Structure (EMS)**

LOW-GRAVITY GROUND FACILITIES

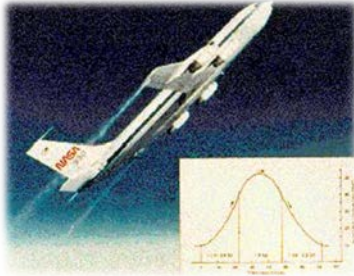


FLIGHT DESIGN AND DEVELOPMENT

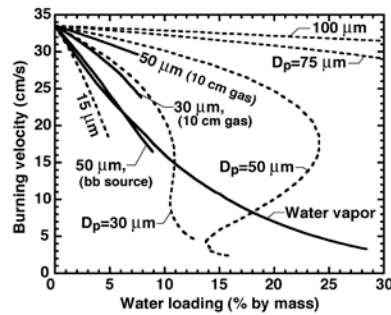
- Design
- Parts selection
- Models and trainers
- Safety documentation
- Fabrication
- Assembly
- Testing
- Environmental tests
- Simulation



SPACECRAFT INTEGRATION

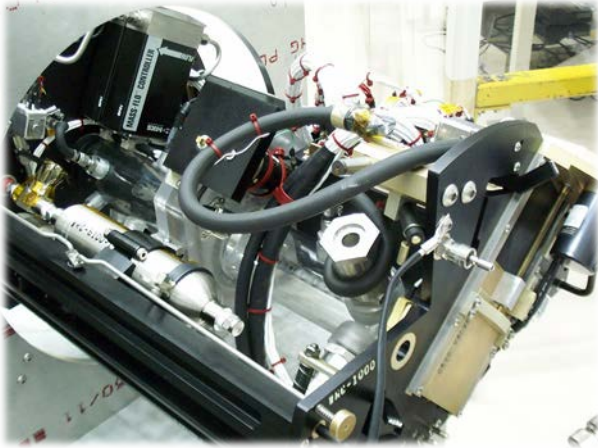


GROUND TESTING



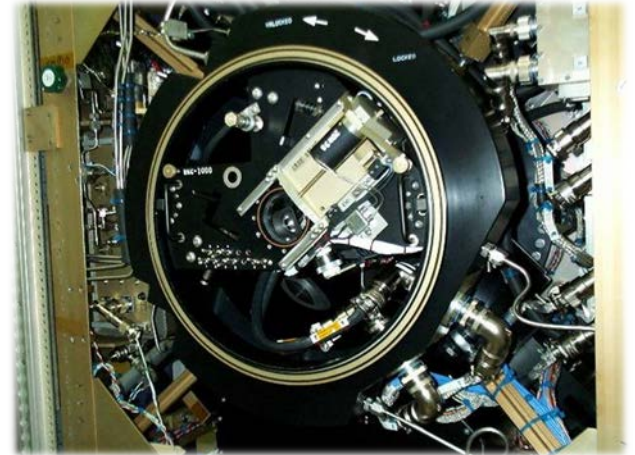
- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS

Hardware Integration



Mist EMS

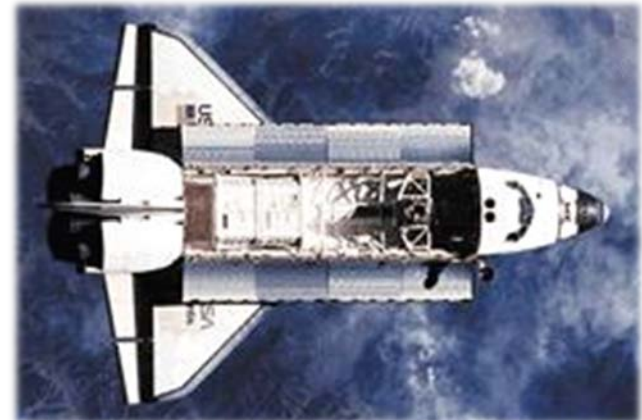
Mist on CM-2 vessel



**CM-2 on
SPACEHAB racks**

**CM-2 on
SPACEHAB**

SPACEHAB on Shuttle



**LOW-GRAVITY
GROUND
FACILITIES**



**FLIGHT DESIGN AND
DEVELOPMENT**

- Design
- Parts selection
- Models and trainers
- Safety documentation
- Fabrication
- Assembly
- Testing
- Environmental tests
- Simulation

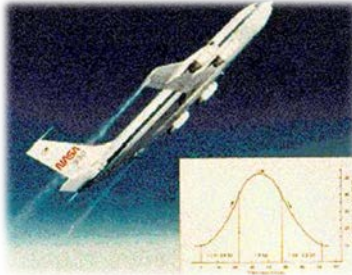


SPACECRAFT INTEGRATION

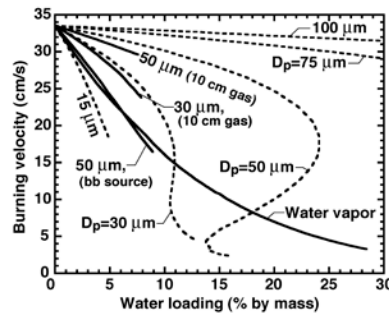
- CM2, SPACEHAB
- Shuttle
- Integration
- Crew training
- Simulation

2003

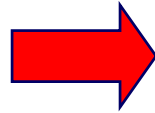
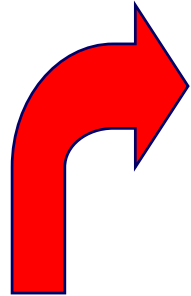
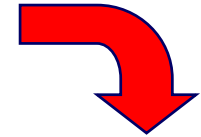
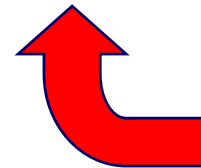
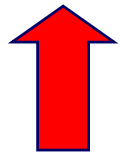
FLIGHT



GROUND TESTING



1997



- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS

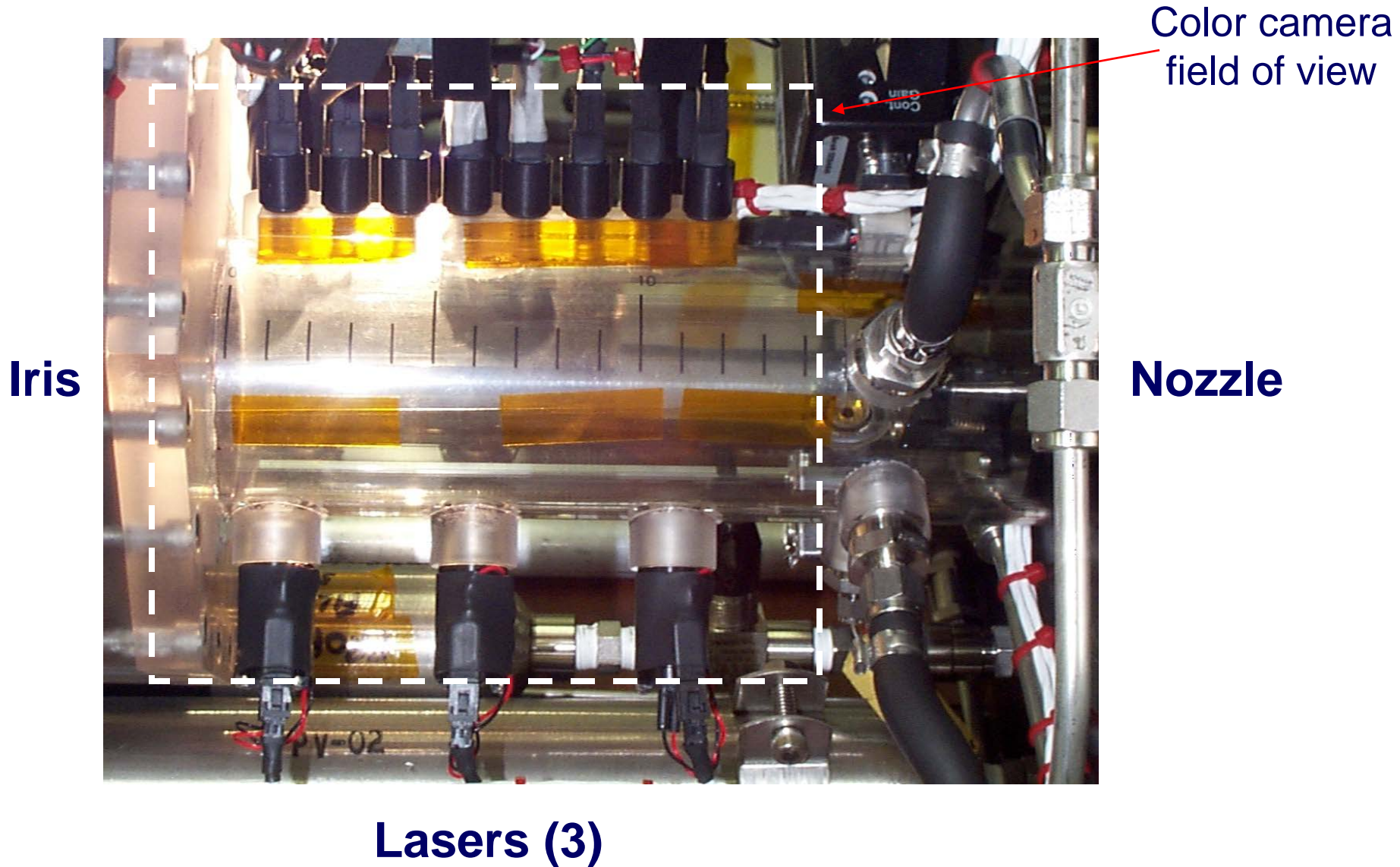
STS-107 Mission (January 16, 2003)



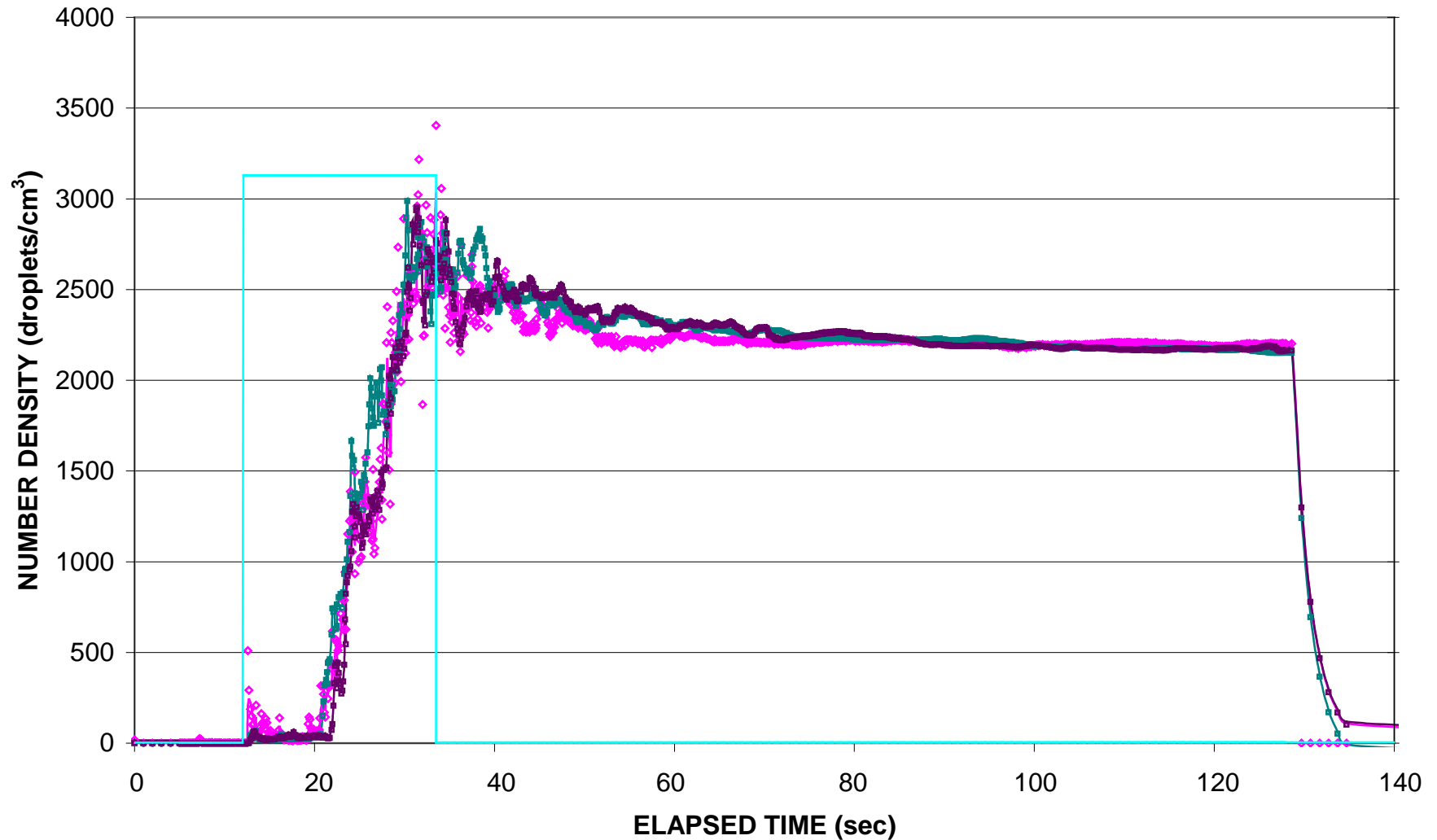
In Orbit ...



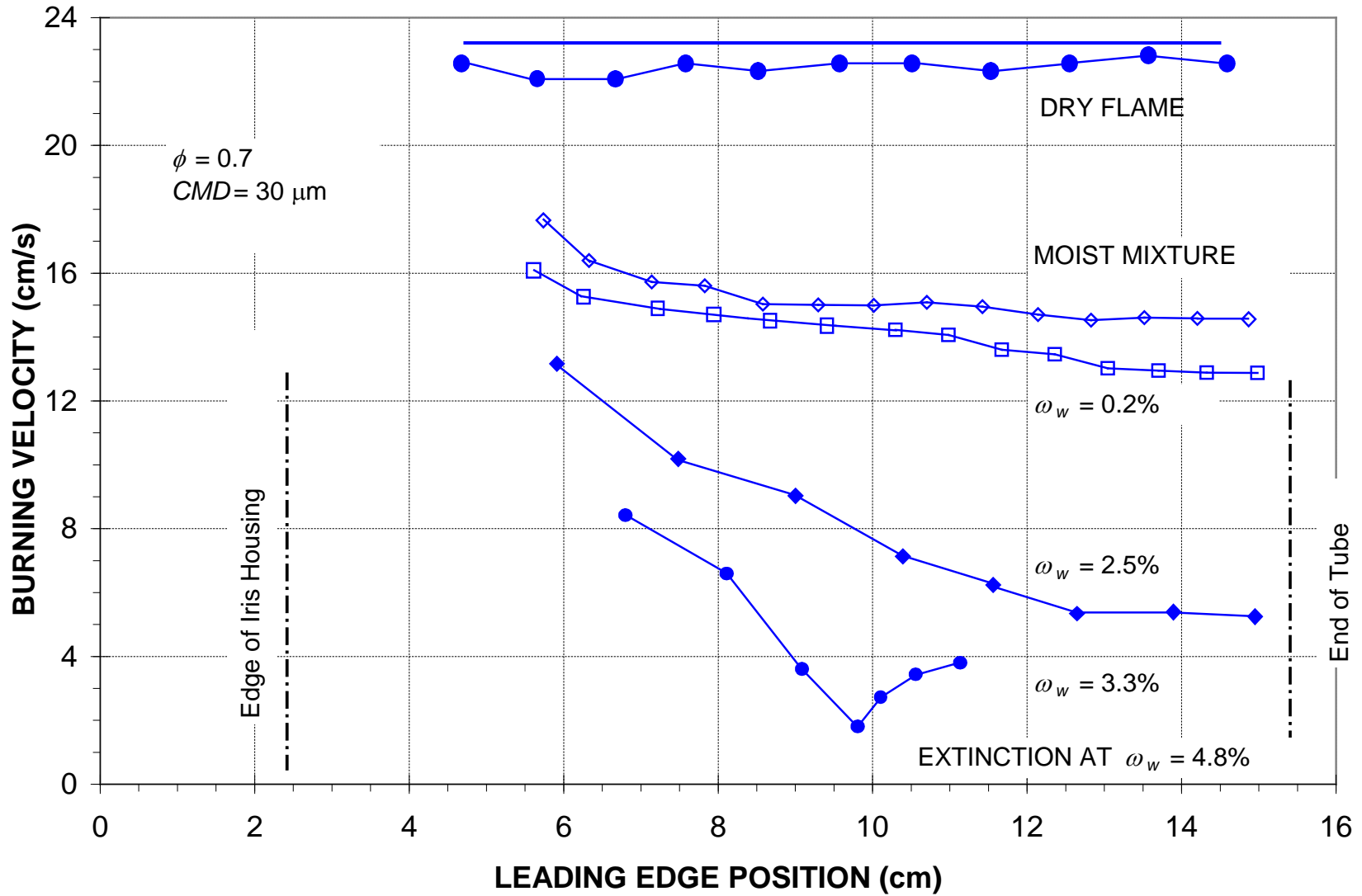
Wet Section of Flame Tube



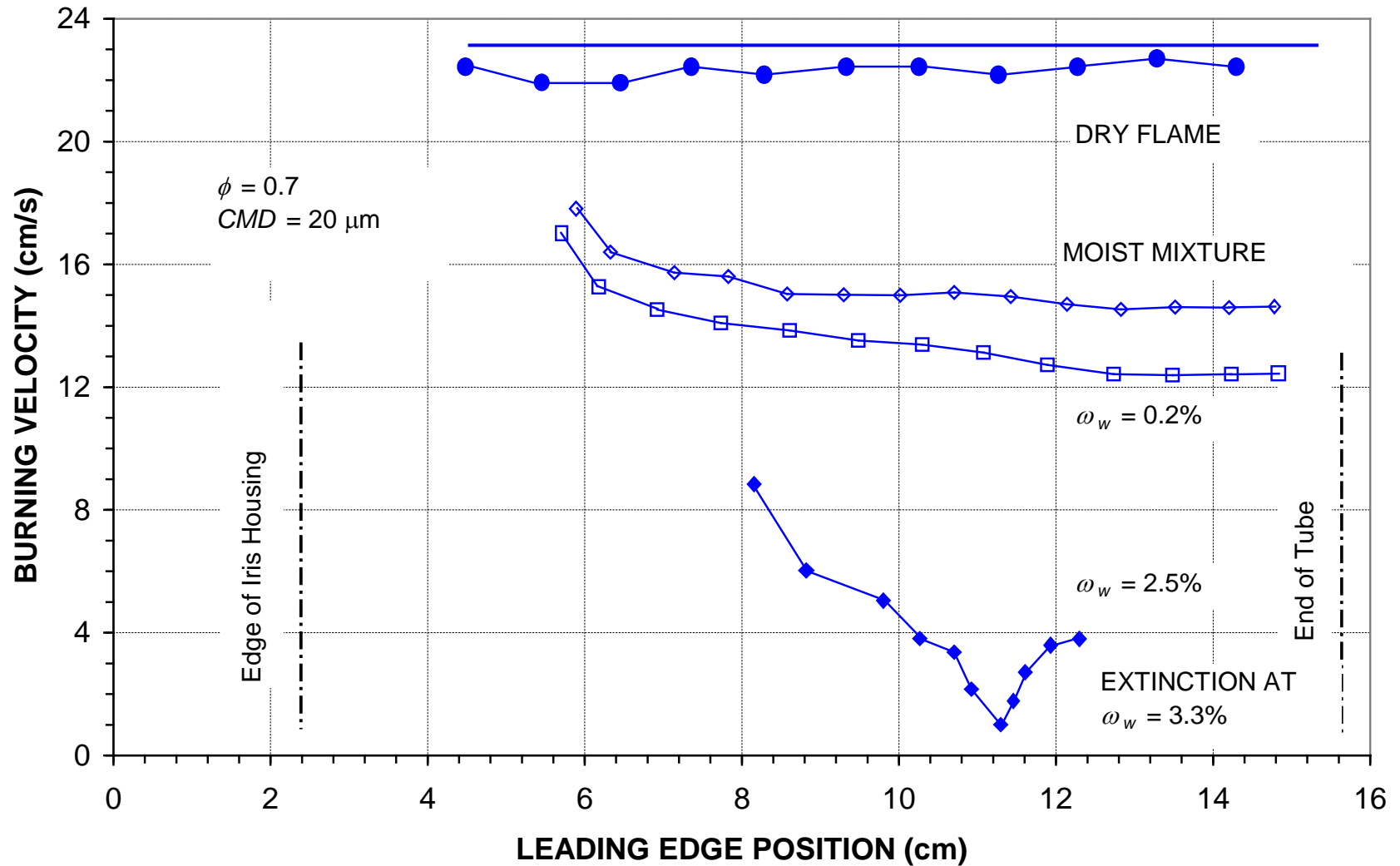
Water mist behavior in microgravity



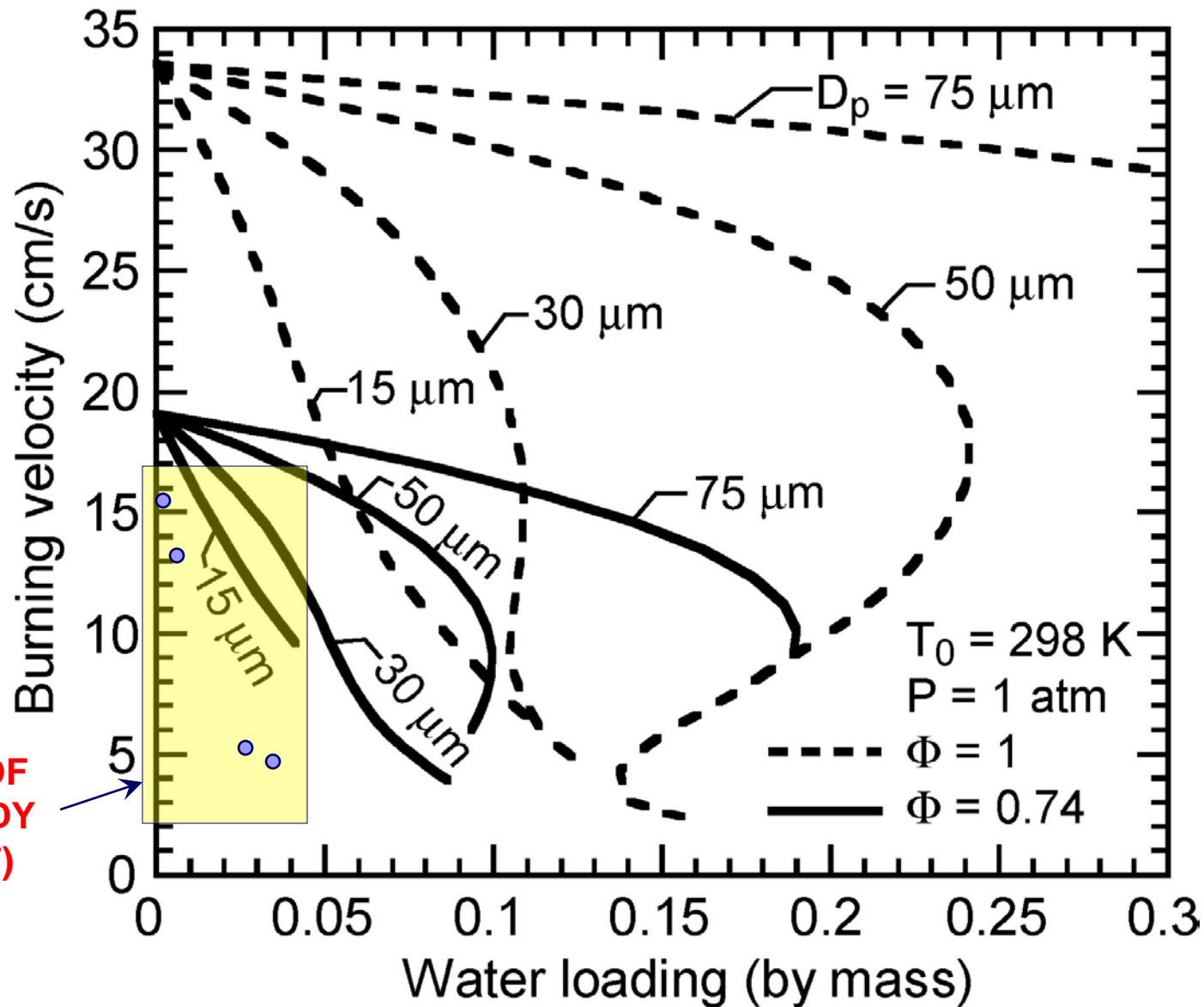
Results (Water loading effects I)



Results (Water loading effects II)



Numerical-Experimental Comparison



February 1, 2003



WFAA

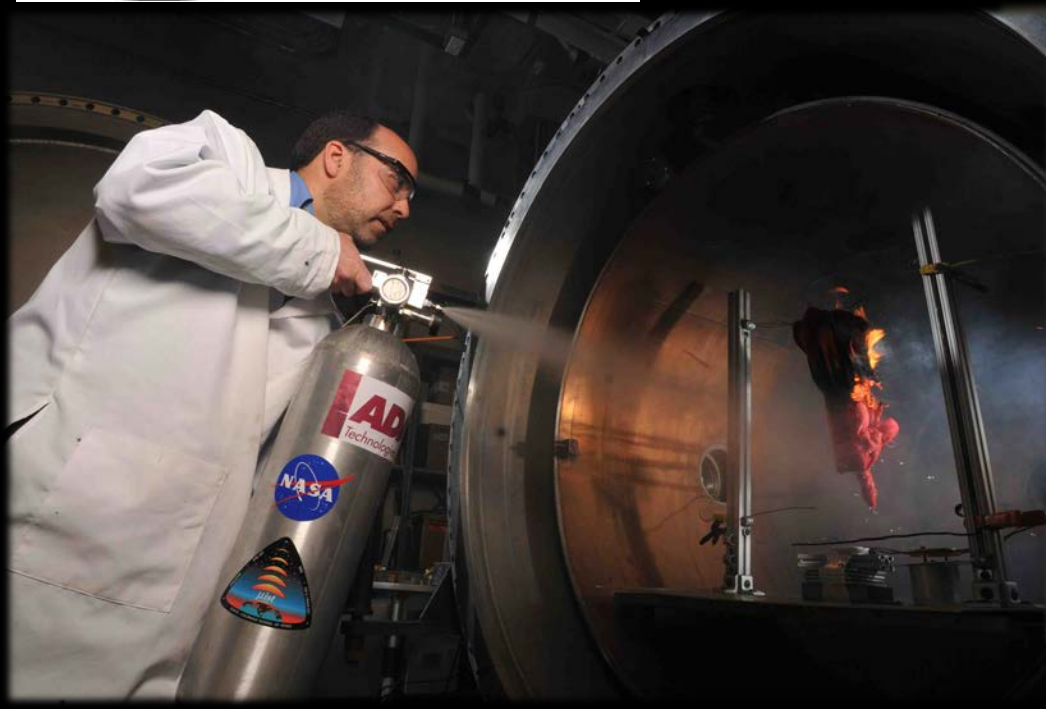
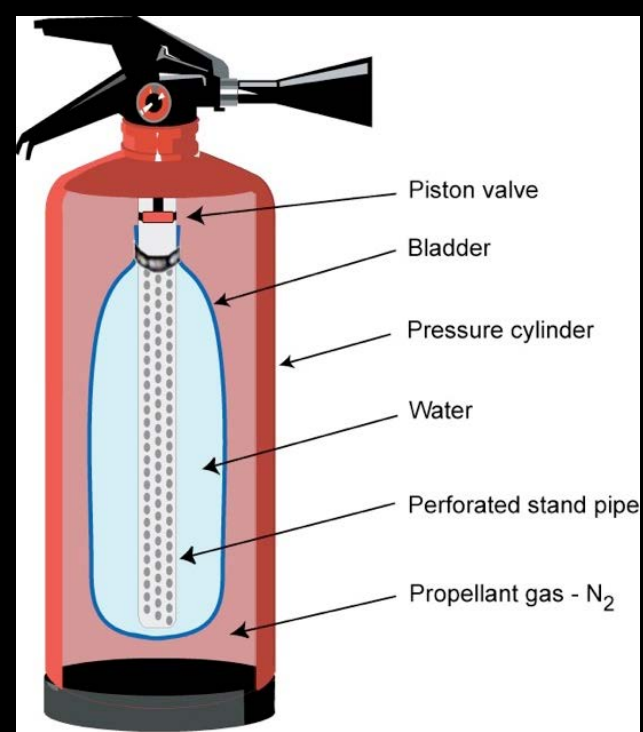
BREAKING NEWS

CNN

OFFICIAL AT JOHNSON SPACE
CENTER: "SHUTTLE LOST"

2003 - 2011 ...





2011 - 2016



wyle

ADA
Technologies, Inc.



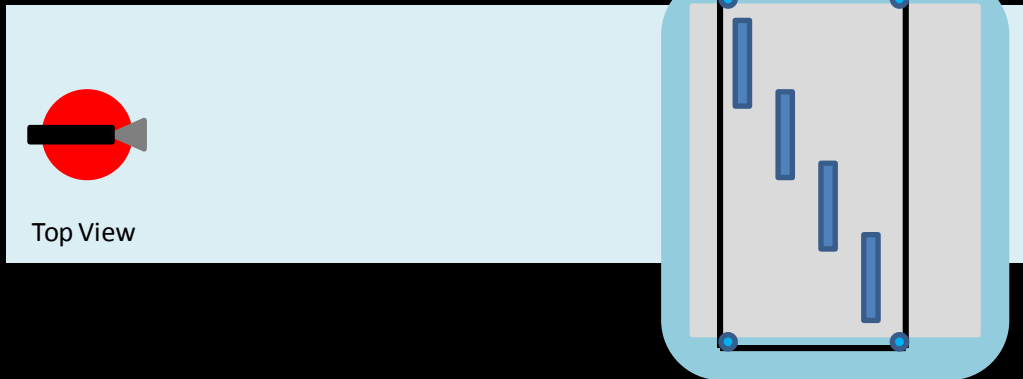
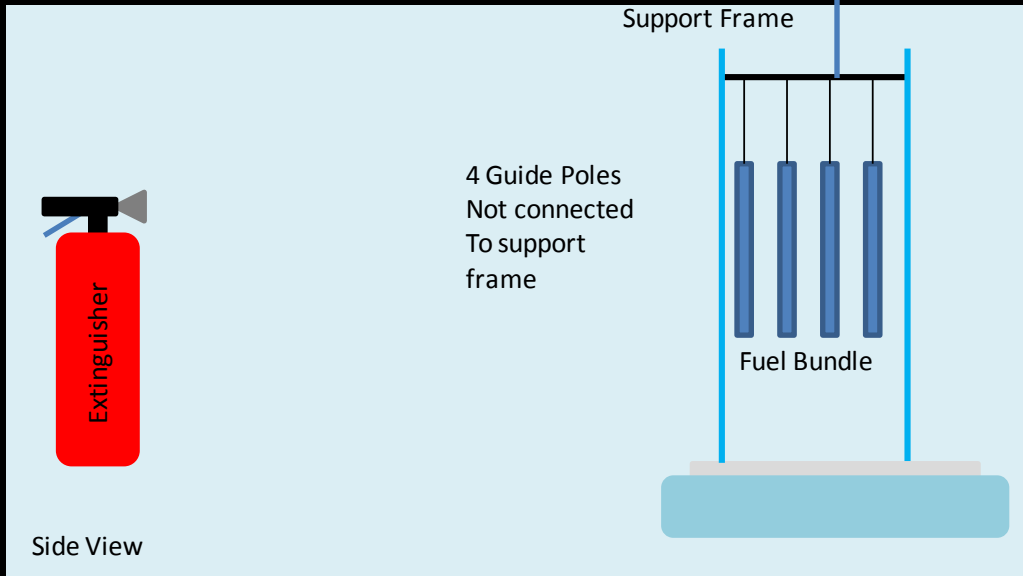
Water Mist Portable Fire Extinguisher (PFE)

Engineering Development Unit (EDU)

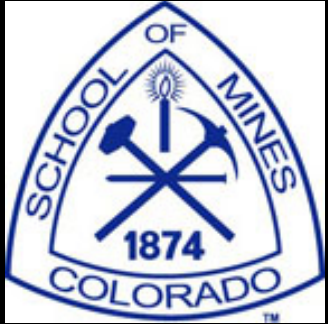


ISS Fire Scenarios (I) – Open Cabin

* Test Configuration

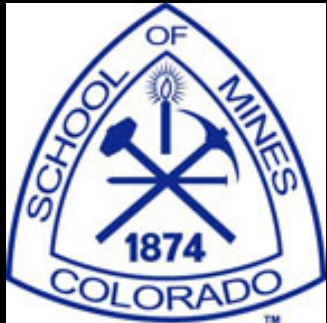


ISS Fire Scenarios (I) – Open Cabin



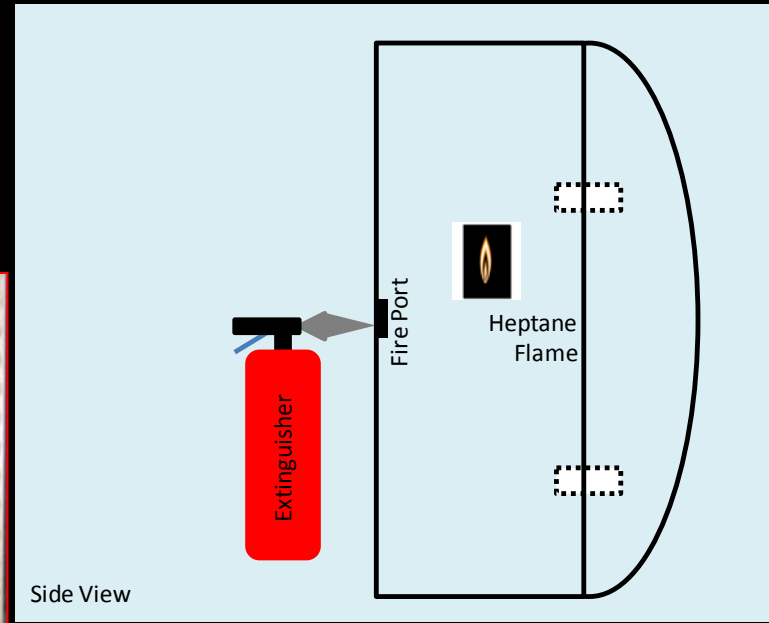
ISS Fire Scenarios (I) – Open Cabin Tests

VIDEO

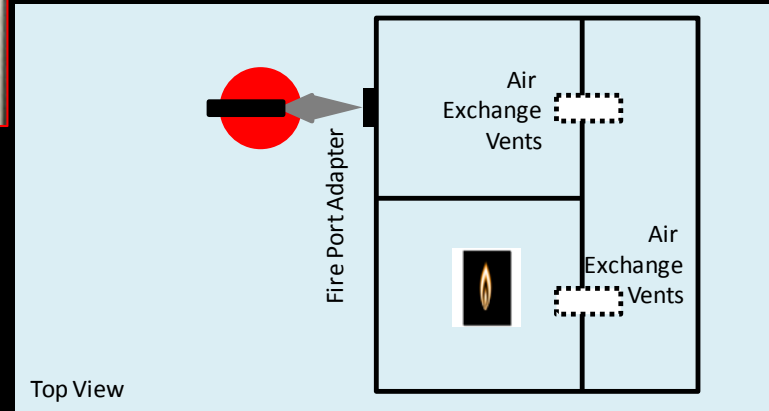


ISS Fire Scenarios (II) – Rack

* Test Configuration



Side View



Top View

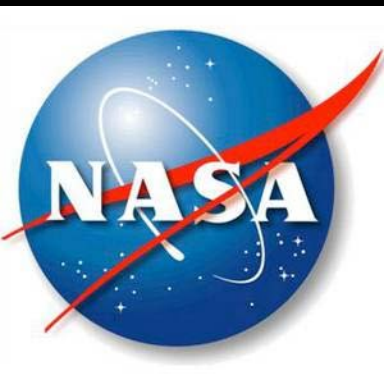


**Glenn
Research
Center**



ISS Fire Scenarios (II) – Rack Tests

VIDEO



**Glenn
Research
Center**



ISS Fire Scenarios (III) – Stored energy: battery

* Test Configuration

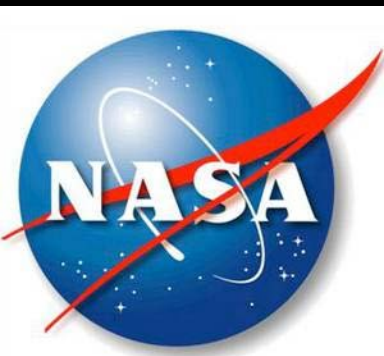
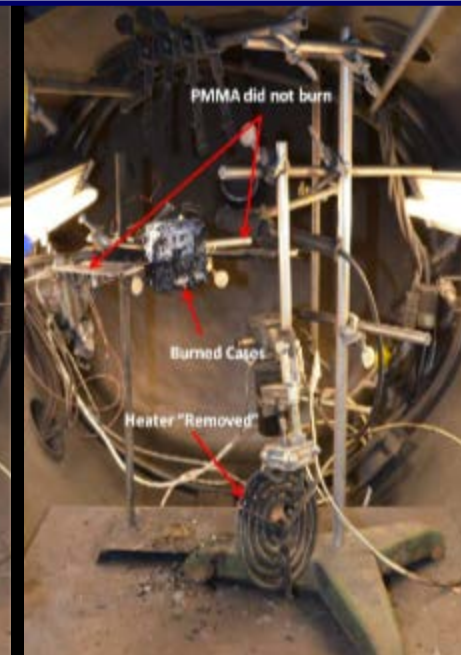
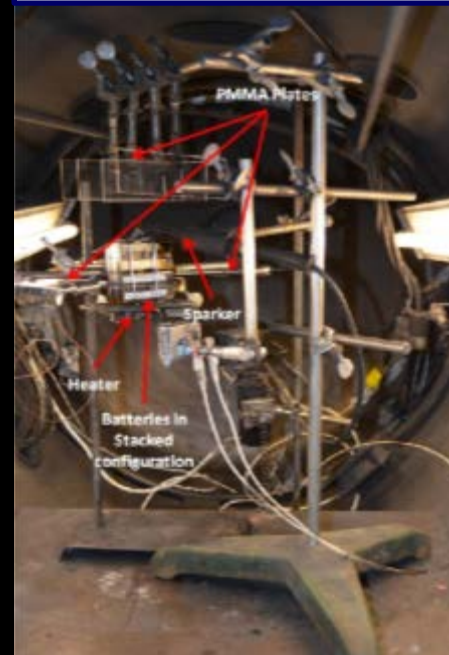
Battery Toxicity Evaluation



Battery Testing with Witness Plate



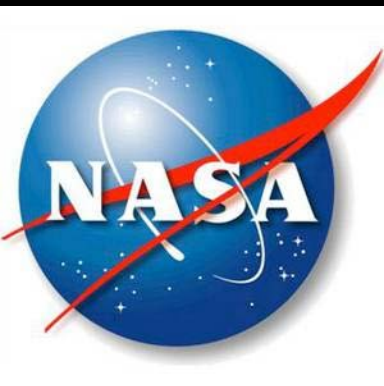
Pre and Post Test Configuration



White
Sands
Test
Facility

ISS Fire Scenarios (III) – Stored energy: battery

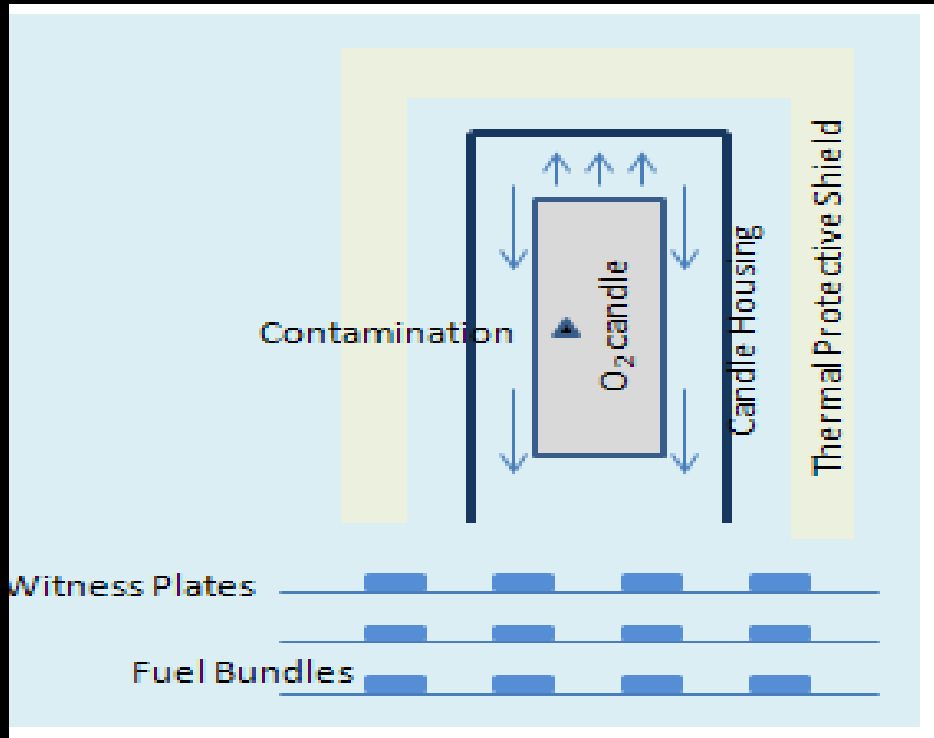
VIDEO



**White
Sands
Test
Facility**

ISS Fire Scenarios (IV) – Stored energy: O₂ candle

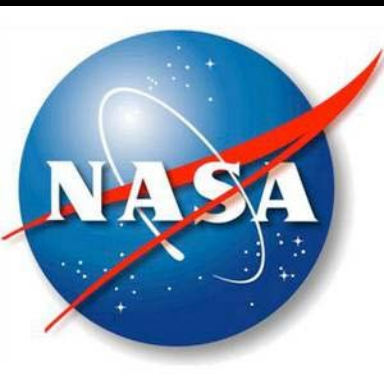
* Test Configuration



**White
Sands
Test
Facility**

ISS Fire Scenarios (IV) – Stored energy: O₂ candle

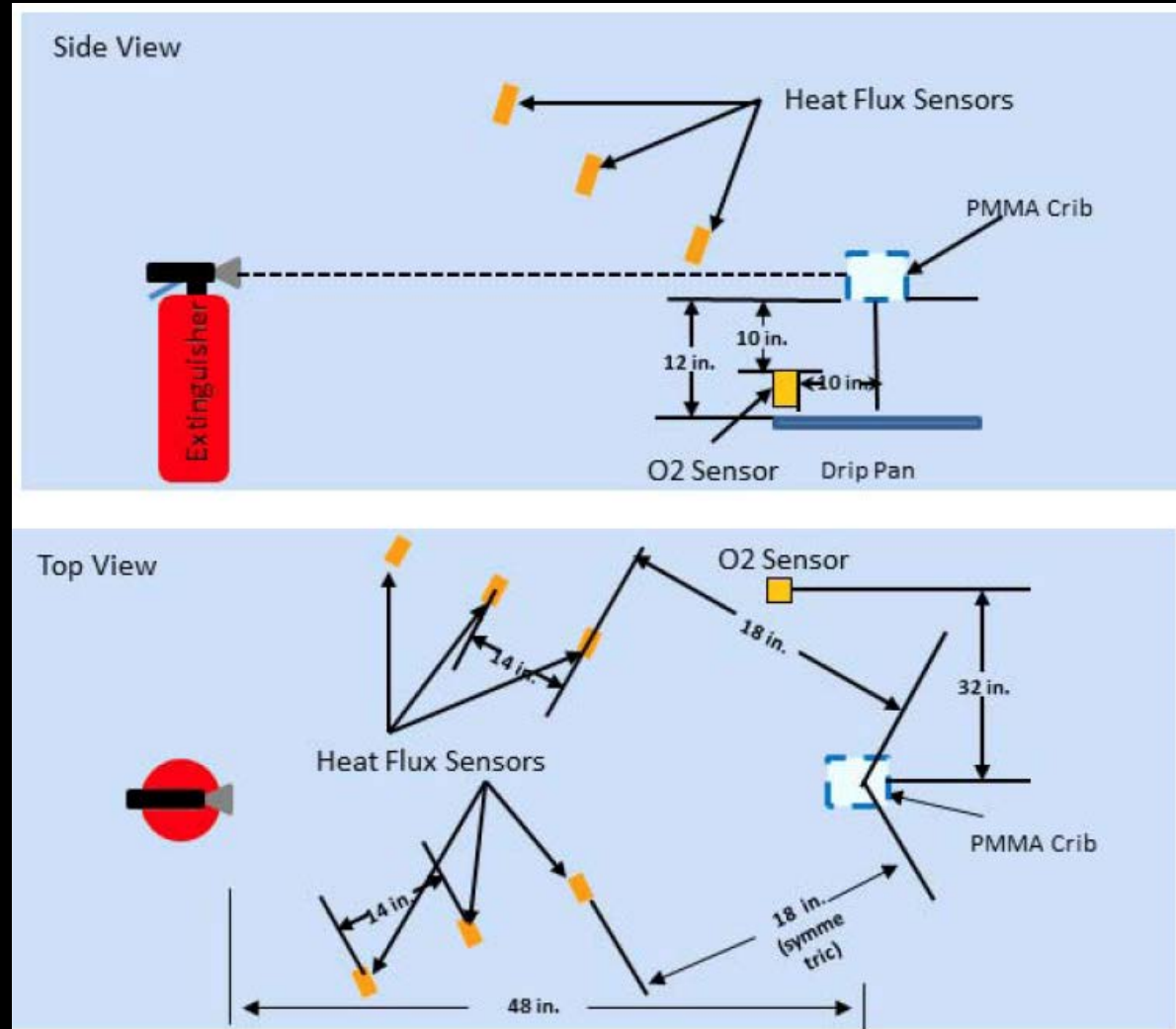
VIDEO



**White
Sands
Test
Facility**

ISS Fire Scenarios (V) – Elevated O₂ content

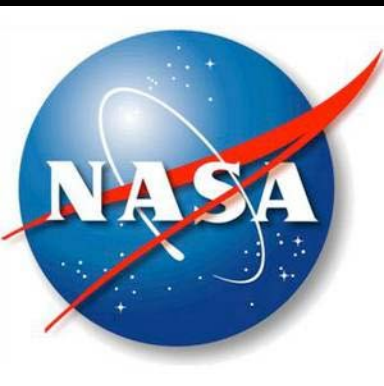
* Test Configuration



White
Sands
Test
Facility

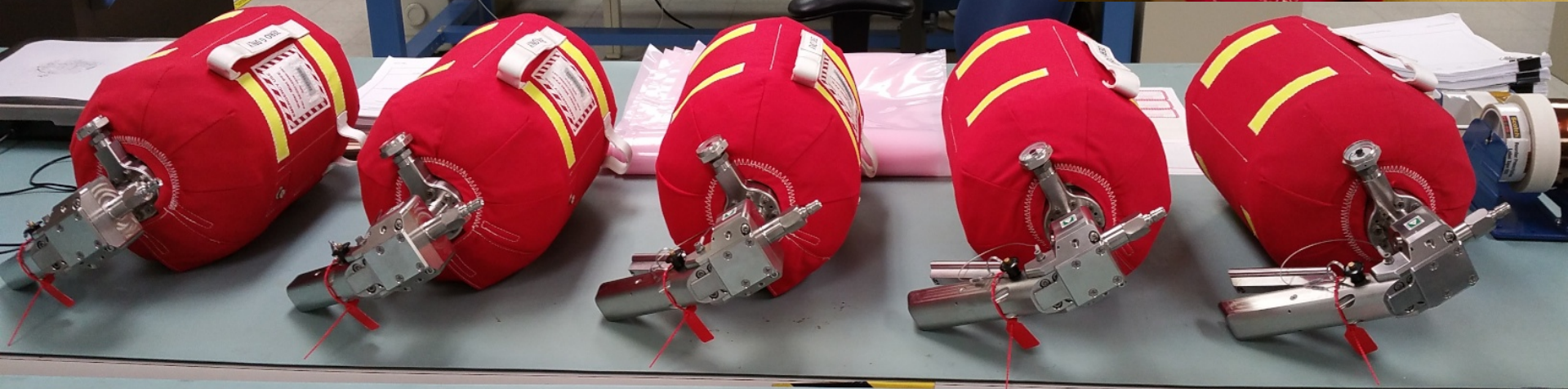
ISS Fire Scenarios (V) – Elevated O₂ content

VIDEO

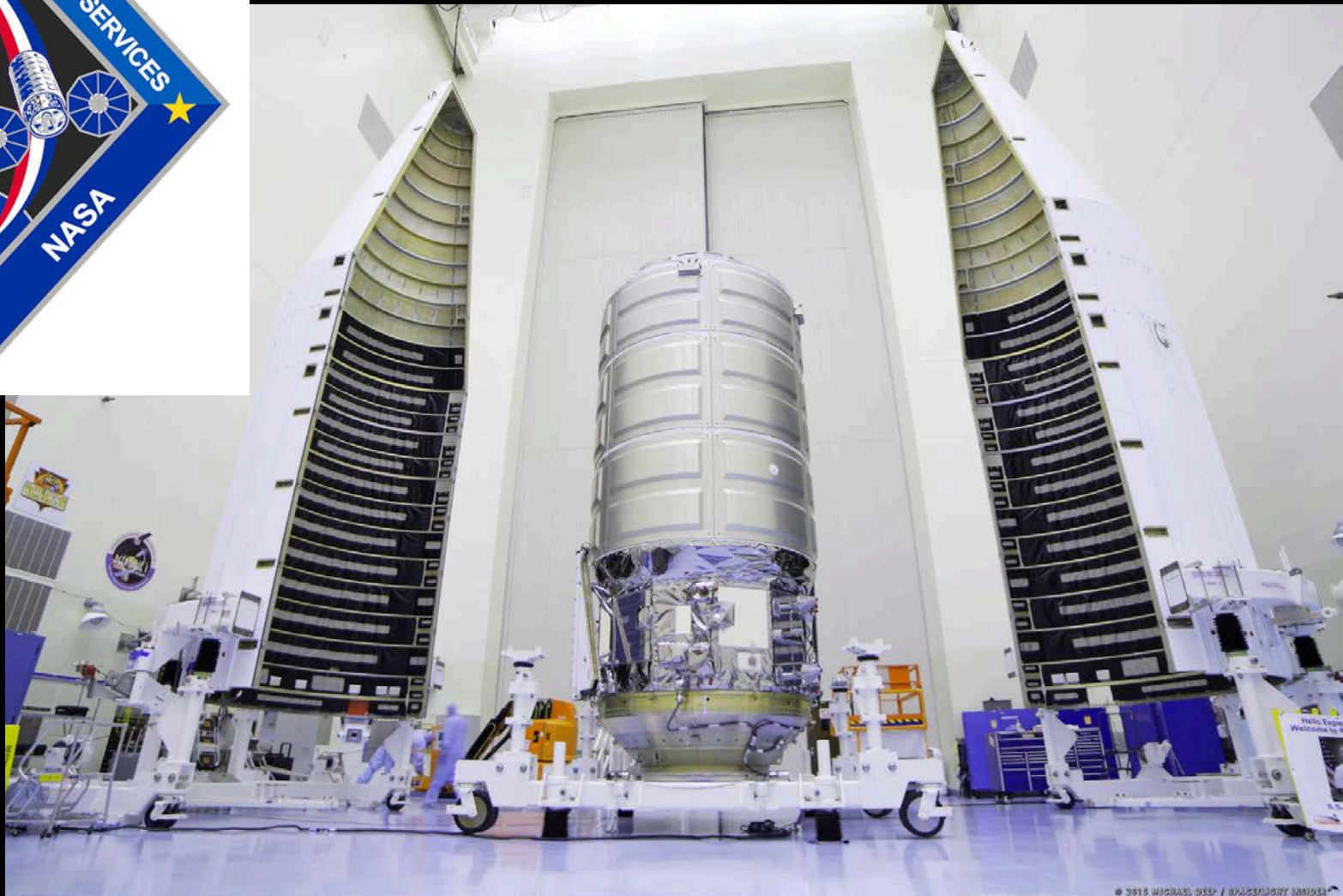


**White
Sands
Test
Facility**

Ready for launch ...



Delivery of first 2 PFEs (Cygnus OA-4 mission)



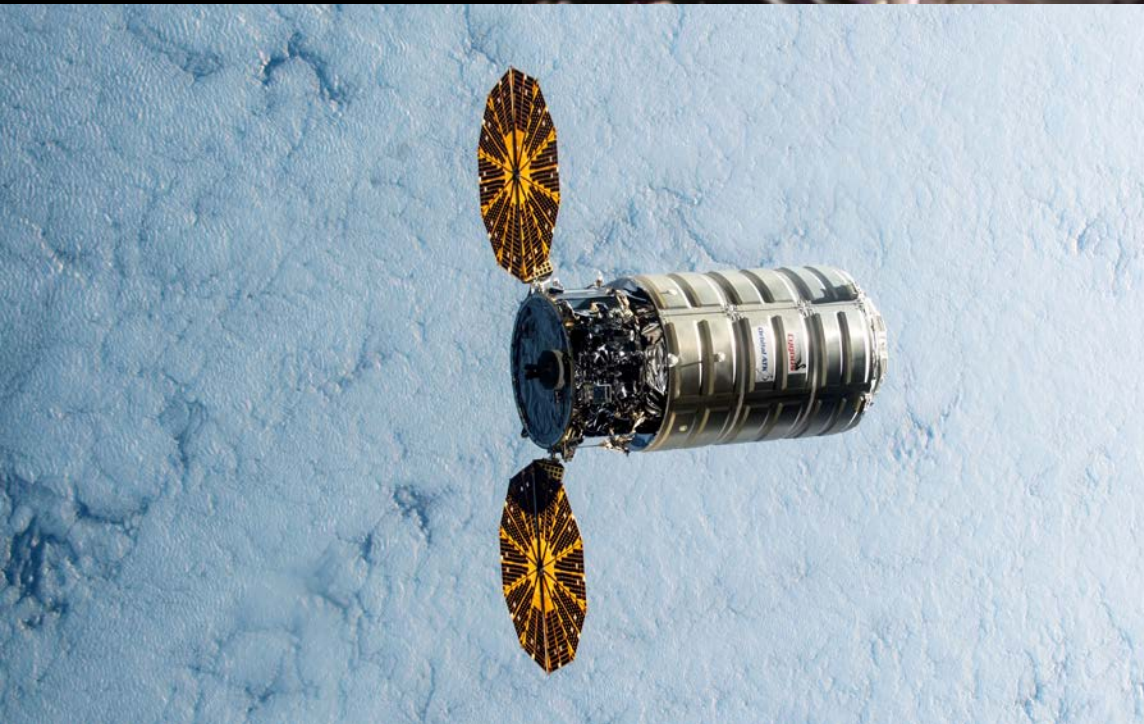
First PFEs delivery (Atlas V launch, 12/06/15)



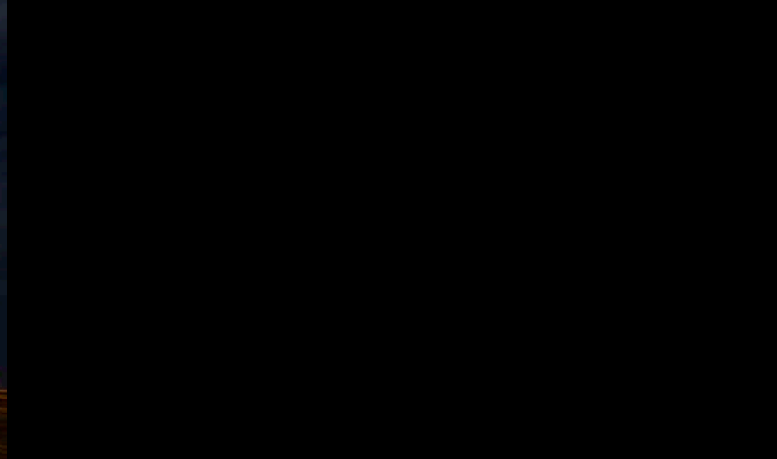
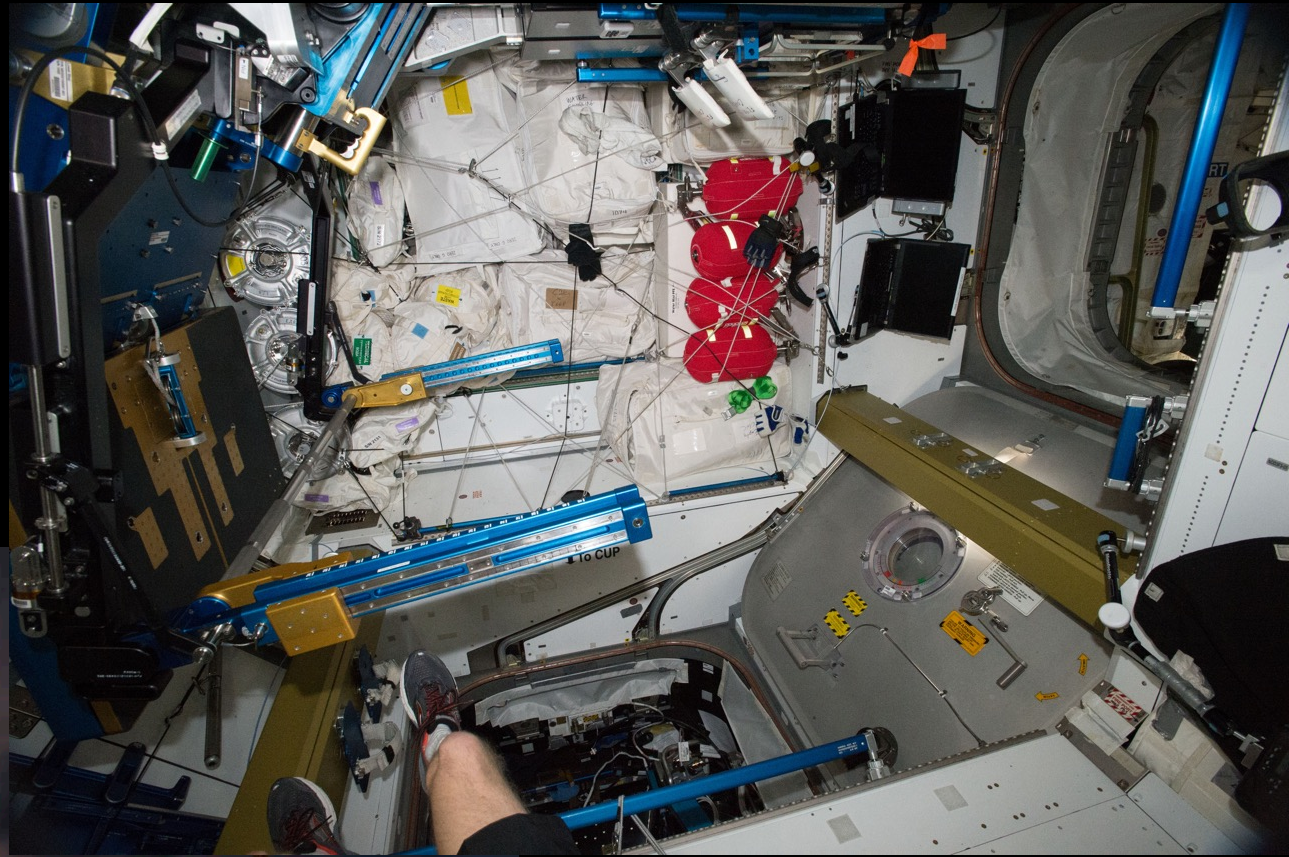
(Atlas V launch, 12/06/15)



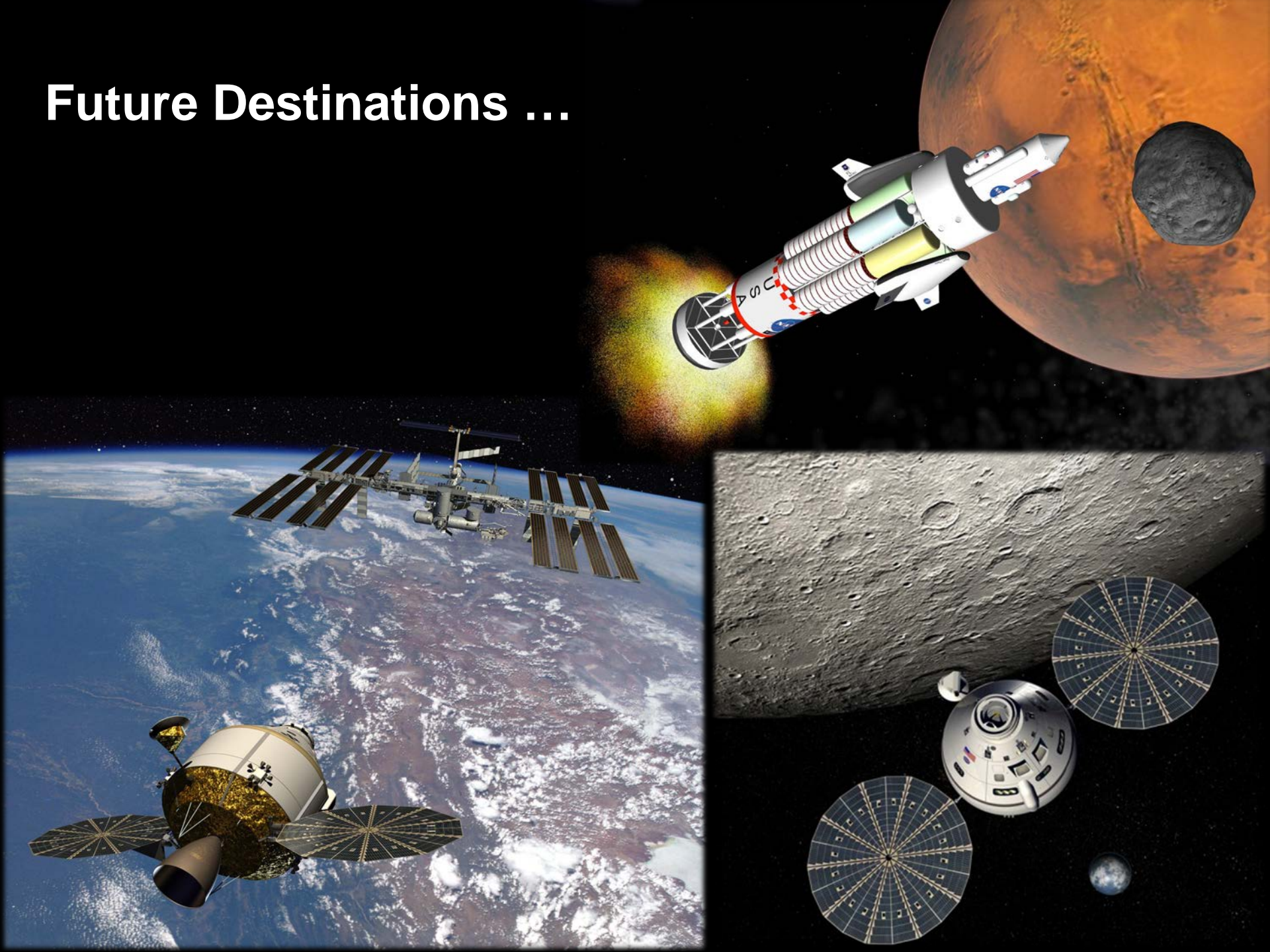
Cygnus arrival to ISS (12/08/15)



Final delivery (6 additional PFEs)



Future Destinations ...



*“The path from dreams to reality does exist.
May you have the vision to find it, the courage to get onto it,
and the perseverance to follow it.
Wishing you a great journey.”*



***Kalpana Chawla
STS-107 mission
Space Shuttle Columbia
January 2003***

“The STS-107 *Mist* crew” In Memoriam

