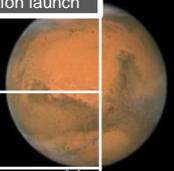


# ISS Technology Demonstration Plan

		On Orbit	Near term	Planning	Timeframe based on demonstration launch		
International Partnership	Human Health, Life Support, and Habitation Systems	Air – CO2	Vozdukh, CDR, Sabatier, Swingbed	CDRA Upgrades <b>2016</b>	ACS, Sabatier, Sabatier, Adv O2 recovery from CO2	 Mars (Hubble image)  Asteroid Ex: Asteroid 243 Ida and its moon (Galileo image)  Earth-Moon (KAGUYA image)	
		Air – O2	Elektron, OGA	NORS, OGA demo, Elektron upgrade	ACS, O2 Gen 1 Upgrades		
		Water	WRS, SRV-K	Separator upgrade	JWRS		alt pretreat, UPA/WPA improvements, Silver ionizer, Next gen UPA, Silver Biocide, Brine processor, Hygiene water system
		Waste	ACY	ACY Improvement	UWMS, Freeze-Dry WMS		Heat Melt Compactor
		Environmental Monitoring	Gas analyzer, TOCA, MCAM, AOM, ANITA	microTAM, CANA, ANITA-2, MIDASS, ISS/Orion air monitor	Conting Air Monitor, Water Quality Monitor, Microbial Monitor		CSA-CP replacement, AMK
	Fire /Protection	OKR water foam, AFOT, IPK insulating	replace O2 mask with filtering mask, water mist PFE, SAFFIRE	Conting Air Monitor, smoke eater			
	Radiation	DOSIS, RAD-N2	REM, EUCPAD, JTEPC, CHENSSI, Radiation Shield	Rad Monitor			
	Crew Health and Performance						
	Space Power and Energy	Power Generation	Advance Solar Array, Advanced photovoltaic	ROSA			
		Energy Storage	Advanced Li Ion Battery, Battery Test bed	Non Flam Li Ion Battery, Regenerative Fuel Cell			
Autonomous Systems	Sensing & Perception		Rendezvous & Inspection Sensor (DDVS)				
	Mobility/ Manipulation	RRM, METERON	Manipulator Autonomy for Robotics, RRM 2, DiX Op w Low Latency Comm	EVA Robot manipulator, Telerobotic w time delays from ground			
	Human-Sys Integ / Autonomy	Robonaut, DTN, Telerobotic control of group of robots, Telerobotic control with time delay, SPHERES	Robotic Caretake	Autonomous Robotics, Robots Working Side-by-Side with Suited Crew, Human Assisted Robot, Dexterous Robot, Human-robotic collaboration			
	Auto Rendezvous/ Docking	SPHERES, VERTIGO	Crew Autonomy for ISS and beyond LEO, Auto Rendezvous and Docking, S/C health monitoring, multipurpose laser comm, RAVEN	Rendezvous & Docking Sys in Deep Space			
	Communication/ Internetworking	SCAN, OPALS		LCRF			
	Position, Navigation & Timing	In-Space Timing and precise Navigation	NICER	Xray Nav			

Planned and Funded

Proposed but NOT Funded

Decision Point

Existing Project Details can be found at the ISS Science Web; <https://iss-science.isc.nasa.gov/searchResults.cfm?searchIndicator=Investigation>  
 Projects related to exploration are listed at each SORR; <https://iss-www.isc.nasa.gov/nwo/nppo/cbp/web/issprogramrws.shtml>

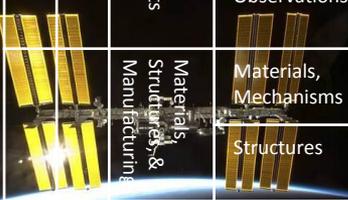
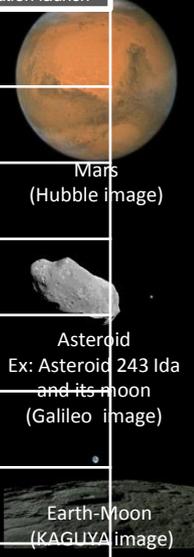
Pre-decisional, For Internal Use Only



Capability Should be demonstrated on ISS

# ISS Technology Demonstration Plan

NRC		International Partnership		Operational Process and Procedures		On Orbit	Near term	Planning	Timeframe based on demonstration launch			
				Operational Process and Procedures	Flight Crew Analogs		1 year on orbit analog	Two, 6 month increments within 500 days	Mars landing surface simulation			
					Autonomous Mission Ops	Comm Delay 1	Increased Crew Autonomy					
				Thermal Management	Cryogenic Systems	SPHERES Slosh	Multipurpose on-board cryogenic system with liquid helium	ZBOT	Cryo Acq and Trans	In-Space Cryogenic Propellant Storage		
					Thermal Control Systems		Deployable Radiators	Advanced Thermal Heatpipes	Slipping flow heat transfer	PCM Thermal Testbed	ICE PCM Heat Dissipation	High Efficient Radiator
					Thermal Protection Sys						THOR	
				EVA				ACES Demo	In-Suit Nutrition	PLSS upgrades/Suit demo		
				Entry, Descent, and Landing Systems	Instrumentation and knowledge	REBR	Entry of space objects into the rarefied upper atmosphere					
					Aeroassist and Entry		Development and launching of nanosatellit	THOR				
				In-Space Propulsion				Electric Prop	Electric Prop			
				Human Exploration Destination Sys	Sustainability & Supportability	Manufacture in Space	Additive Manufacturing Facility	Heat Melt Compactor	On-board parts repair & manufacturing			
					Advanced Habitat Systems	UBNT	Detection of Puncture by means of acoustic					
				Science Instruments	Remote Sensing / Sensors							
					Observations							
					Materials, Mechanisms		Change in mech characteristics caused by space	Formation of polymeric materials and structures in microgravity	Antibacterial, Anticontamination and Self-Cleaning Coating	Mechanisms for Long Duration, Deep Space Missions	Material - Semi conductor, biotill protects	
				Materials, Structures, & Manufacturing								
							BEAM					



Planned and Funded

Proposed but NOT Funded

Decision Point

# ISS Technology Demonstration Plan

## Notes:

ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG (T&OWG)

- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
- **Current Revision can be found at:** <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>

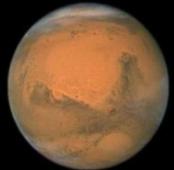
This demonstration plan highlights the **highly recommended** technology demonstrations on ISS, and is a **subset of the many additional demonstrations planned**. Please contact the T&OWG for information concerning the entire list of demonstration activities.

Each technology area has a supporting demonstration plan specific to that technology area identifying technology needs, demonstrations schedule, and the technical progress these demonstrations are making toward the technology goals.

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MRICB and Russia manifest - ISS payload manifests

Detailed tech area goals provided by HAT team, paper NASA/TM—2012-217670 “Critical Technology Determination for Future Human Space Flight”



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)



# ISS ECLS Technology Demonstration Plan

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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
<https://www.globalspaceexploration.org/>

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MRICB - ISS manifest

ECLS SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Sogo Nakanoya	Robyn Gatens (L)	
	Johannes Witt	Satoru Tachihara	Jordan Metcalf (B)	
	Norbert Henn (DLR)		Bob Bagdigian	
	Juergen Hill (DLR)		John Lewis	
			Jason Dake	
			Ariel Macatangay	
			Benny Toomarian	
			Terri Bradshaw	



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)

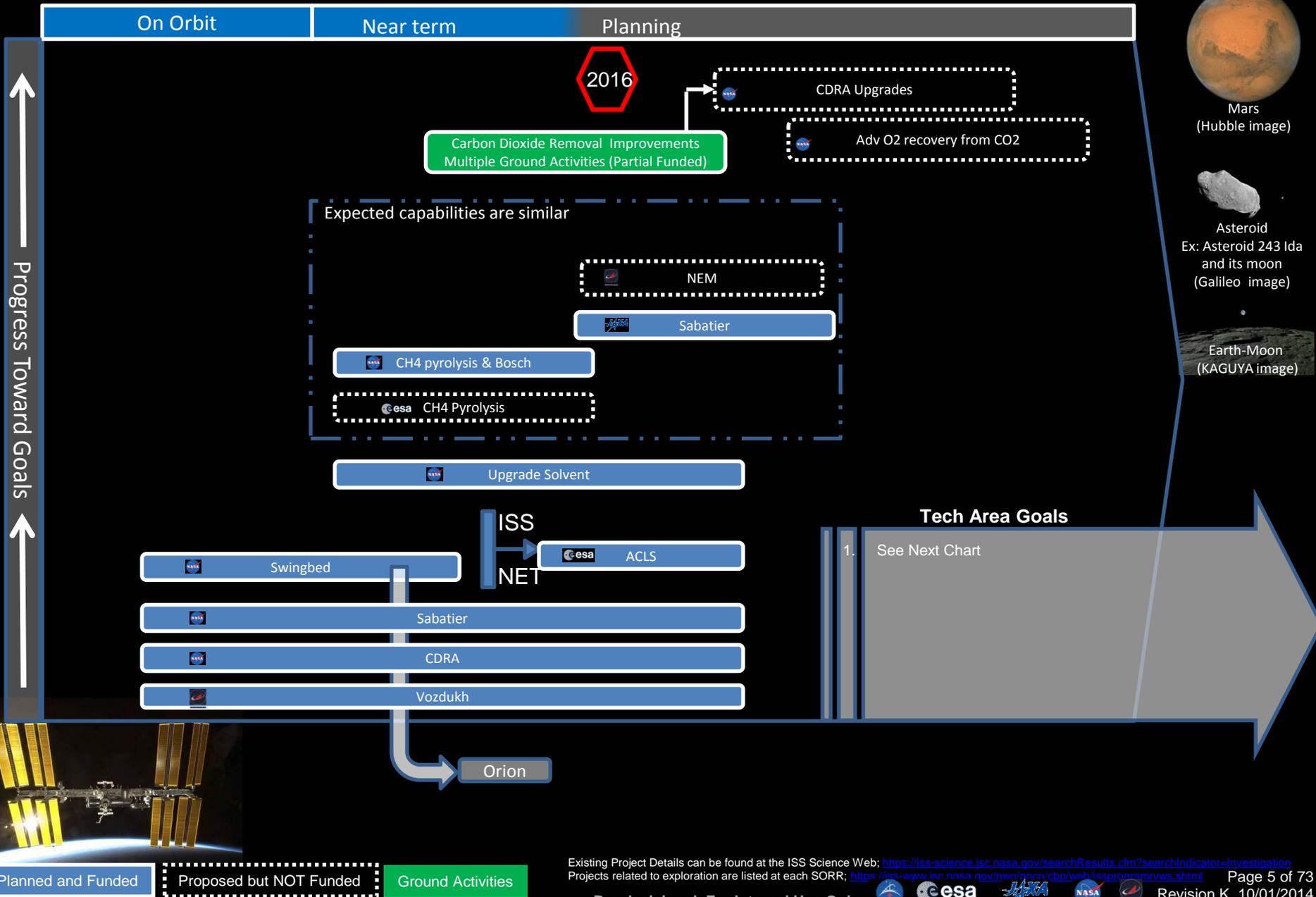


Earth-Moon  
(KAGUYA image)

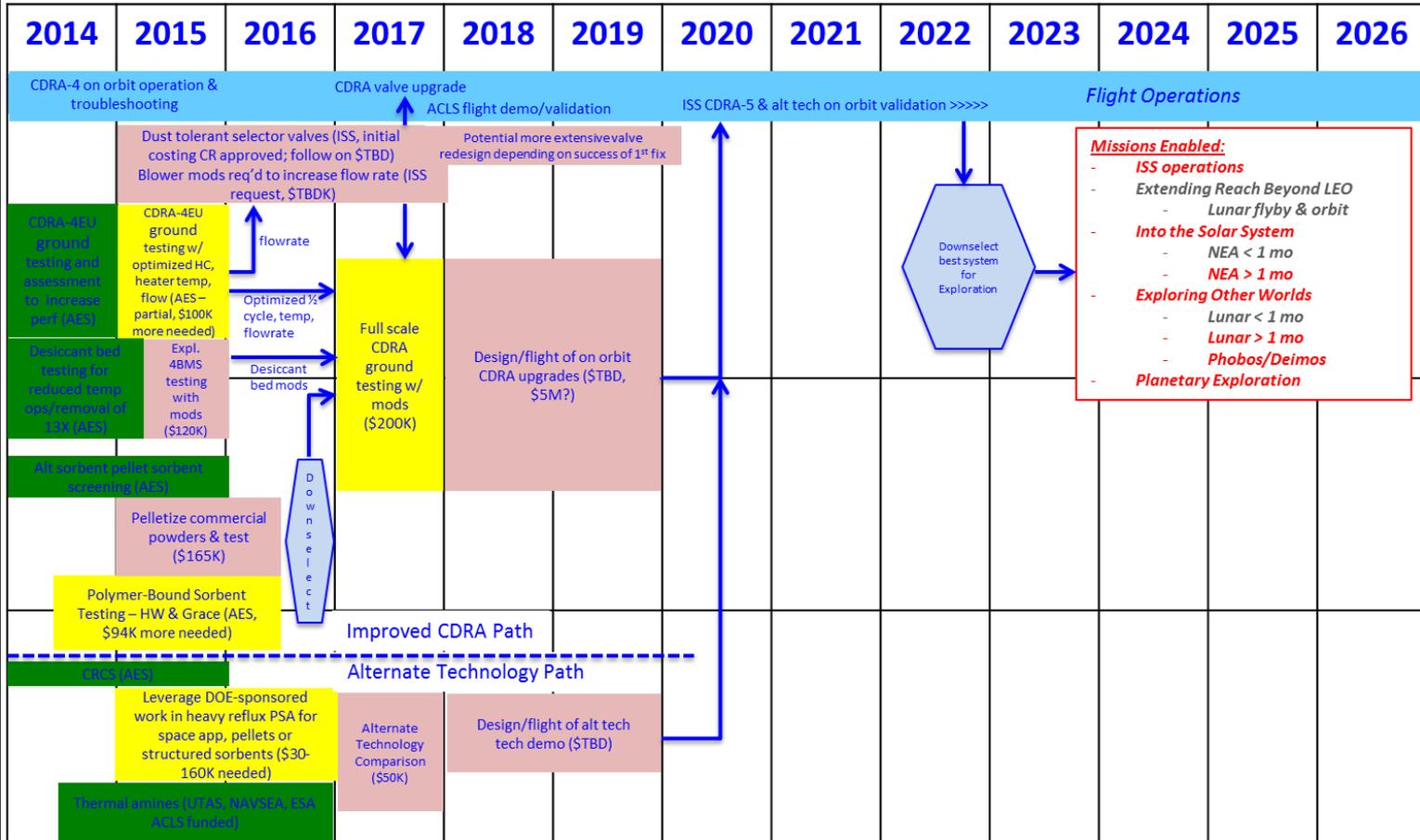


# ISS ECLS Technology Demonstration Plan

Air - CO2



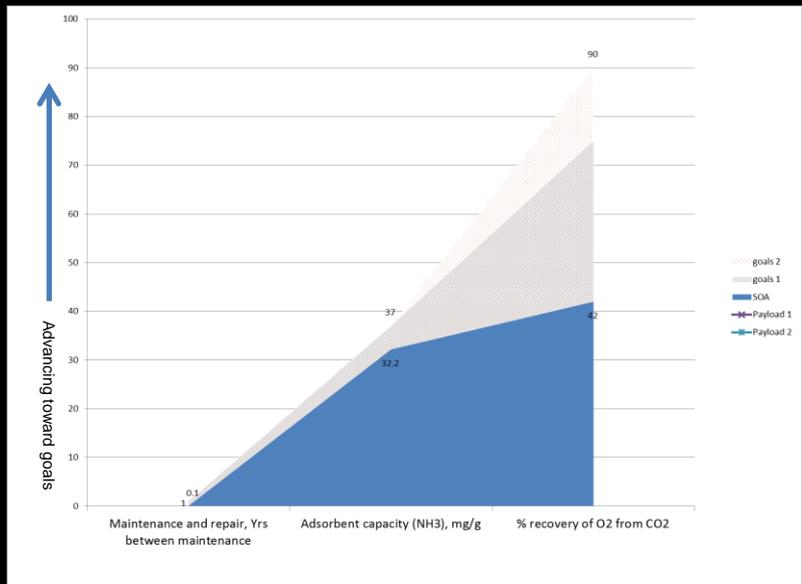
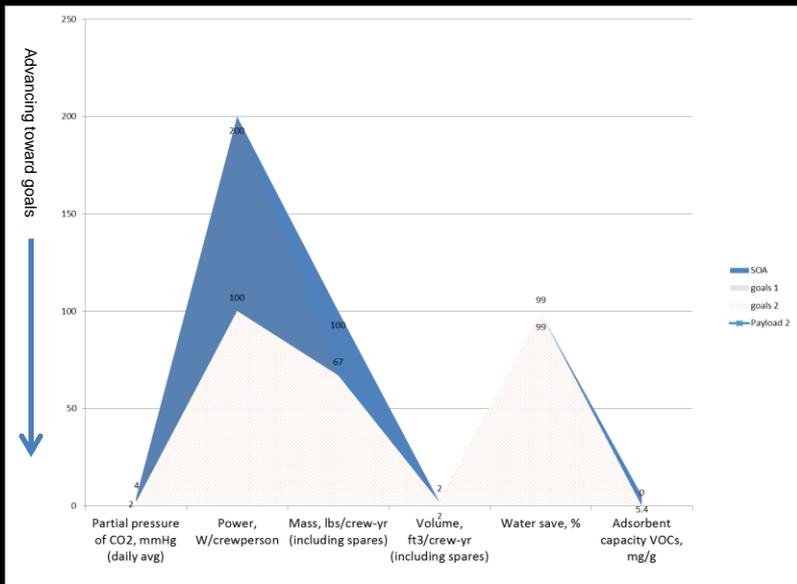
# Fiscal Year



# ISS ECLS Technology Demonstration Plan

Air – CO2

## Technical Goals:



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

## Opportunities to burn down risks:

1. Minimum 2 years run time on orbit?

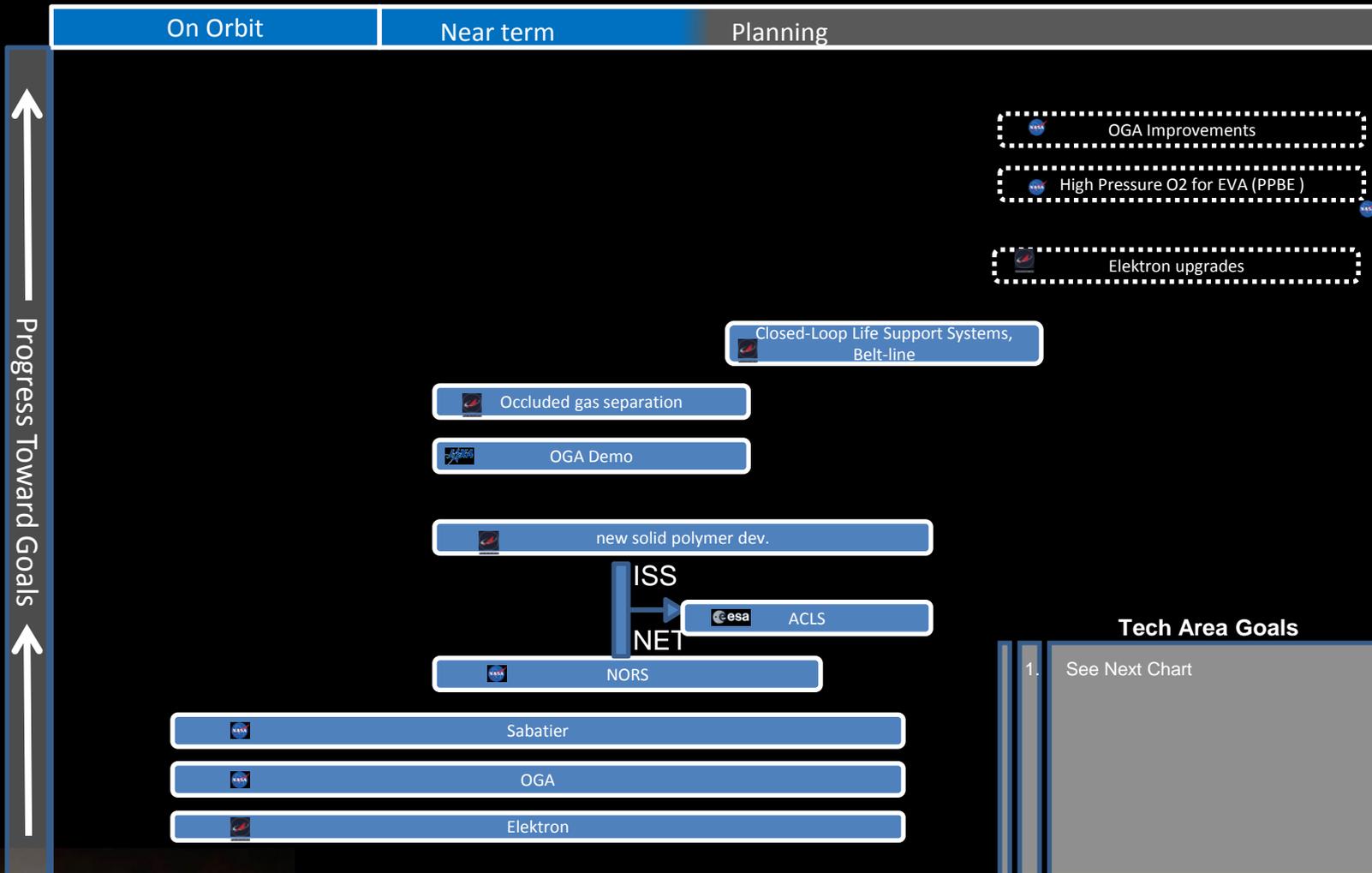
## Dependencies / Standards / Decisions needed:

1. Decision on requirement change to lower PPM CO2 from 4 to 2?



# ISS ECLS Technology Demonstration Plan

Air - O2



Mars (Hubble image)



Asteroid Ex: Asteroid 243 Ida and its moon (Galileo image)



Earth-Moon (KAGUYA image)



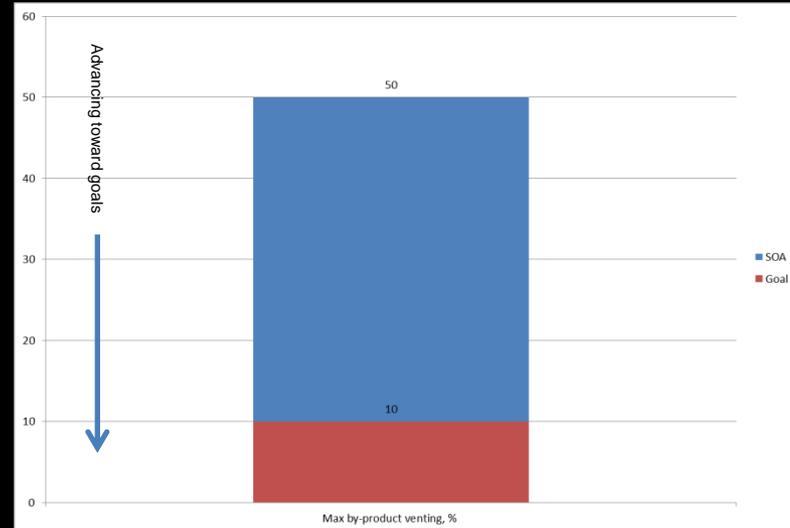
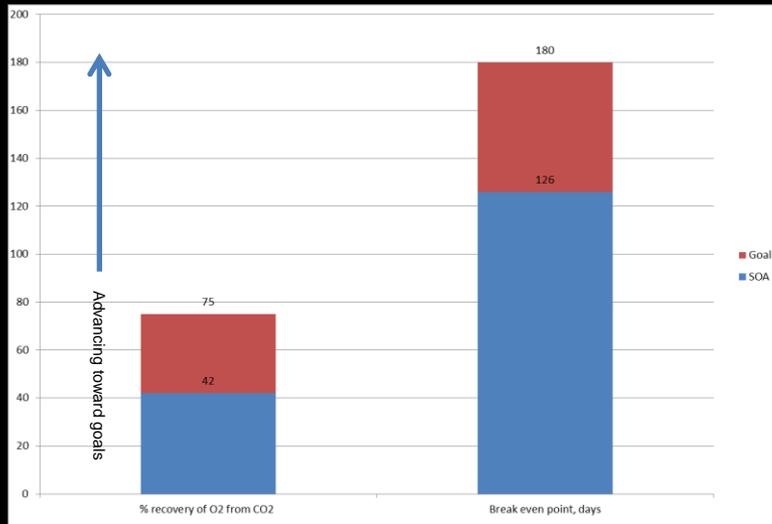
Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS ECLS Technology Demonstration Plan

Air – O<sub>2</sub>

## Technical Goals:



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

## Opportunities to burn down risks:

1. Minimum 2 years run time on orbit?

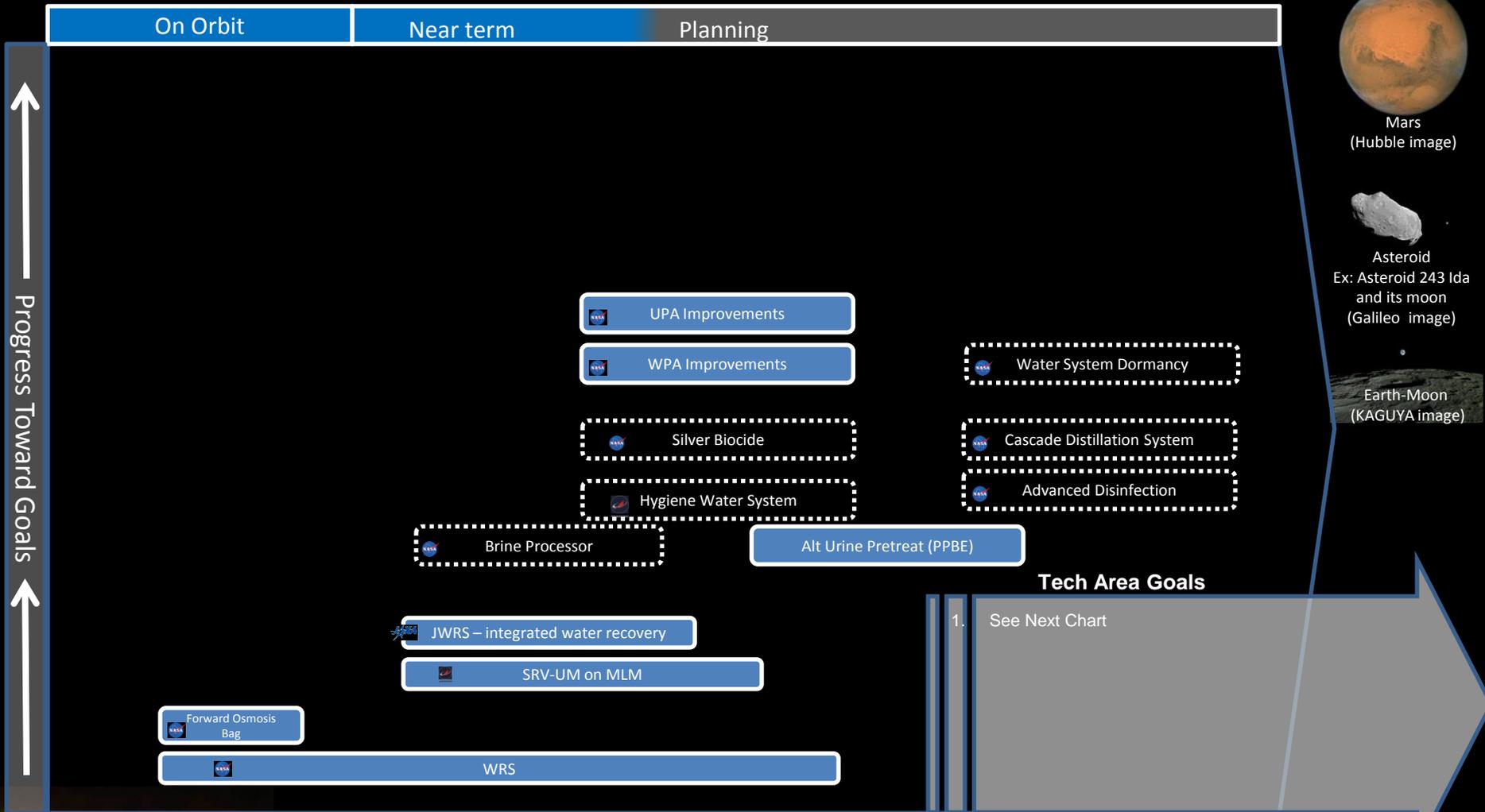
## Dependencies / Standards / Decisions needed:

1. EVA purity requirements?



# ISS ECLS Technology Demonstration Plan

## Water

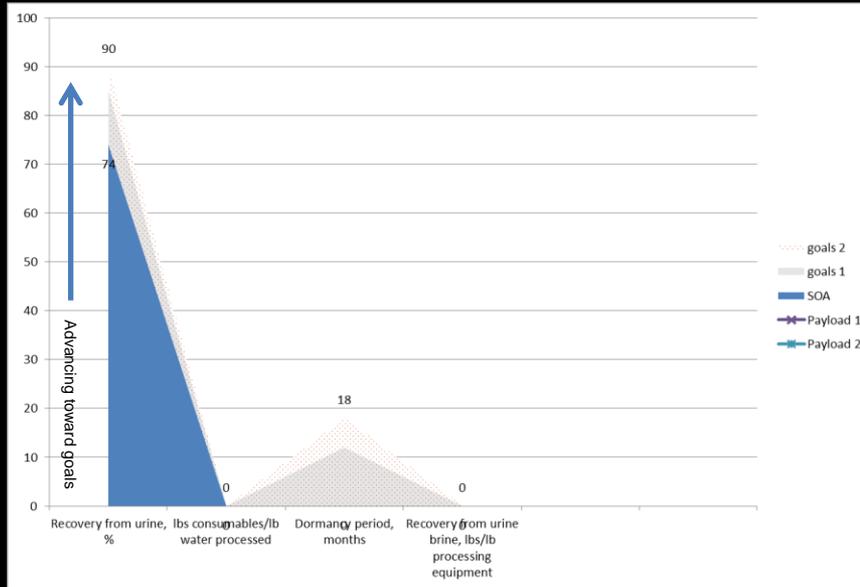


Planned and Funded | Proposed but NOT Funded | Ground Activities

# ISS ECLS Technology Demonstration Plan

## Water

### Technical Goals:



### Opportunities to burn down risks:

1. Minimum 2 years run time on orbit?

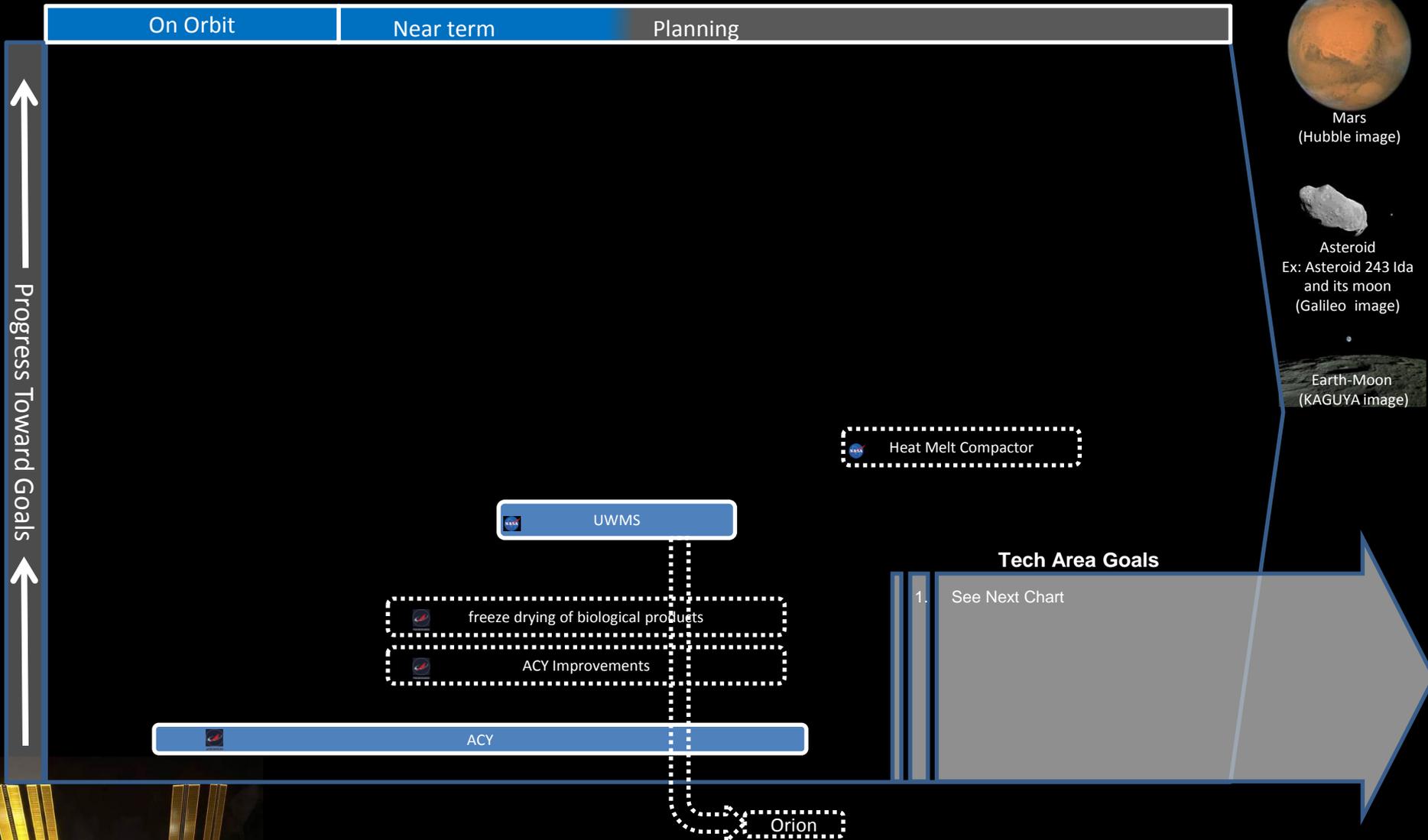
### Dependencies / Standards / Decisions needed:

1. ?



# ISS ECLS Technology Demonstration Plan

## Waste



Planned and Funded | Proposed but NOT Funded | Ground Activities



# ISS ECLS Technology Demonstration Plan

## Waste

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

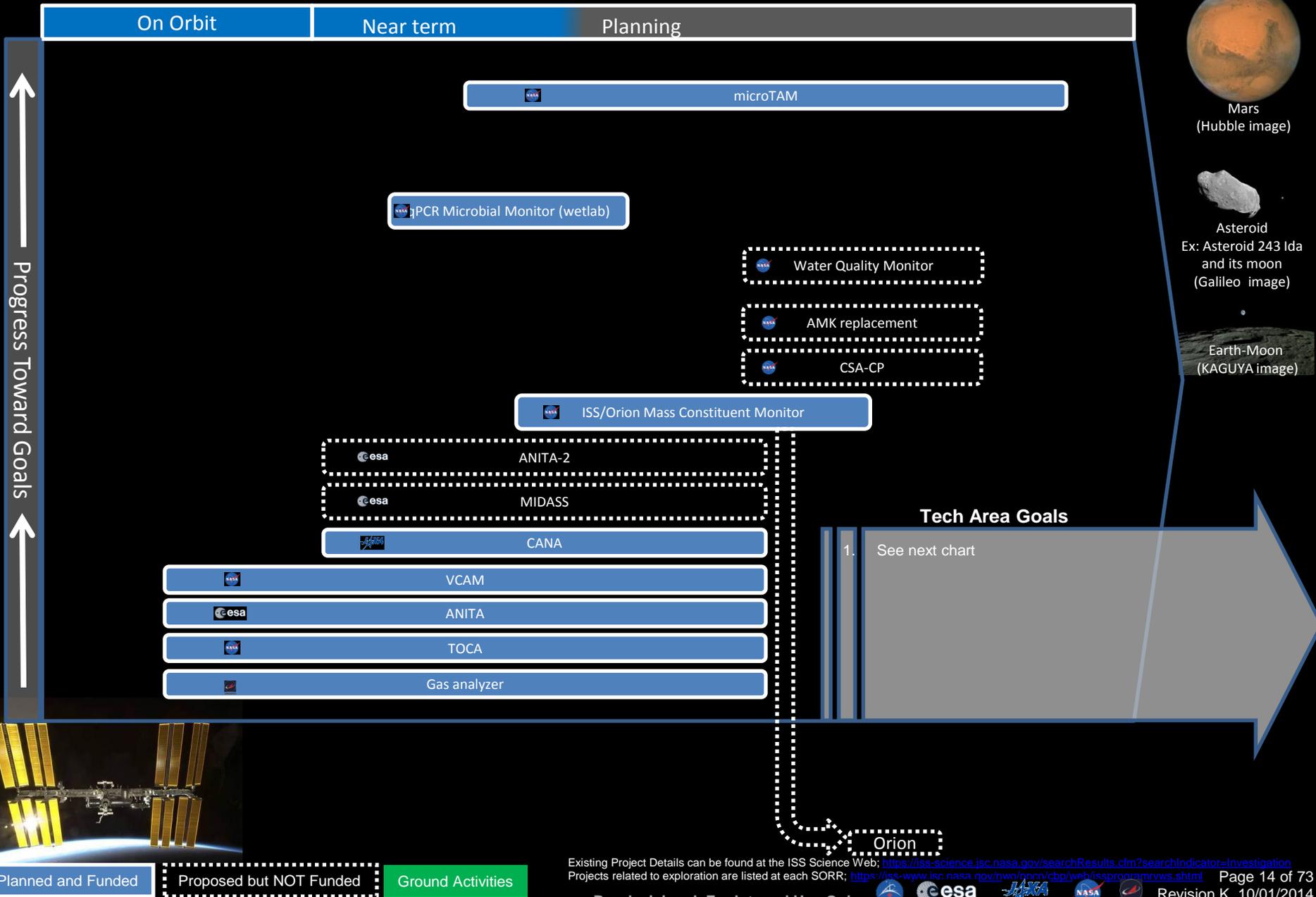
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS ECLS Technology Demonstration Plan

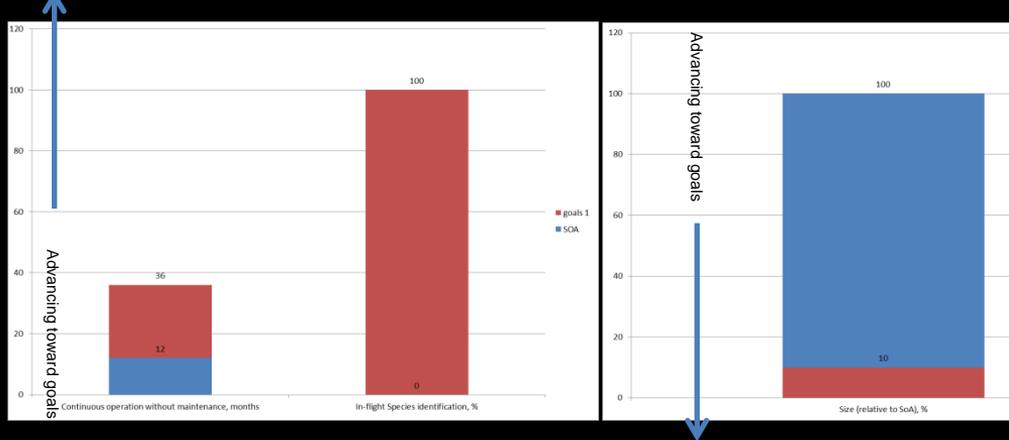
## Environment Monitoring



# ISS ECLS Technology Demonstration Plan

## Environment Monitoring

### Technical Goals:



### DRAFT Target Gas List (ver 07-31-2014)

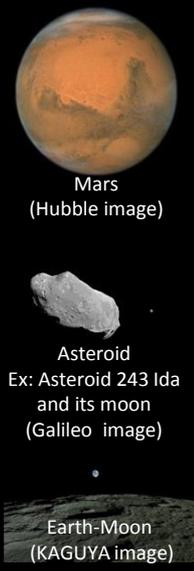
ANITA SDTO Target List	Concentration Range			
	mg/m <sup>3</sup>		ppm	
	low	high	low	high
Hexane	0.01	0.5	0.003	0.142
Formaldehyde	0.01	0.1	0.008	0.081
Acetaldehyde	0.1	0.5	0.056	0.333
Pentanal (C3-C8 Aliphatic Sat. Aldehyde)	0.01	0.5	0.003	0.142
Hexanal (C3-C8 Aliphatic Sat. Aldehyde)	0.01	0.5	0.002	0.122
Acrolein (Propenal)	0.01	0.1	0.004	0.044
Methanol	0.1	1	0.076	0.763
Ethanol	1	7	0.531	3.715
2-Propanol	0.1	1	0.041	0.407
1-Butanol	0.05	1	0.016	0.330
Acetone	0.1	1	0.042	0.421
2-Butanone	0.1	1	0.034	0.339
Benzene	0.05	1	0.016	0.313
Toluene	0.1	1	0.027	0.265
ortho-Xylenes	0.1	1	0.023	0.230
meta, para-Xylenes	0.1	1	0.023	0.230
Styrene				
Isopropyl Benzene				
Ammonia	1	10	1	14
Ethyl acetate	0.1	1	0.028	0.277
Octamethylcyclotetrasiloxane	0.1	2	0.008	0.165
Hexamethylcyclotrisiloxane	0.1	2	0.011	0.220
Decamethylcyclopentasiloxane	0.1	2	0.007	0.132
Dichloromethane	0.05	1	0.014	0.288
1,2-Dichloroethane	100	1000	13	130
Perfluoropropane (Freon 218)				
Ethyl benzene	0.1	4	0.027	1.084
	0.01	0.1	0.002	0.023

Combustion Products	Range	Accuracy
carbon monoxide	5-1000 ppm	5-50 ppm ±20%; 50-1000 ppm ±10%
HCN	1-50ppm	1-50ppm ±25%
HCL	1-50ppm	1-50ppm ±25%
HF	1-50ppm	1-50ppm ±25%
or HX (HCl+HF)	1-50ppm	1-50ppm ±25%

Major Constituent Gas	Specification Accuracy			Typical Improved Accuracy
	% by volume	Range (mm Hg)	mm Hg	
Ambient Pressure Range 13.9 to 15.2 psia				
N2	+/- 2%	335 - 800	+/- 16	+/- 2.1
O2	+/- 2%	0 - 300	+/- 6	+/- 0.61
H2	+/- 5%	0 - 50	+/- 2.5	+/- 0.4
Methane	+/- 5%	0 - 25	+/- 1.25	+/- 1.0
H2O	N/A	0 - 25	N/A	N/A
CO2	+/- 3%	0 - 15	+/- 0.45	+/- 0.31
Ambient Pressure range 10.0 to 13.9 psia				
N2	+/- 4%	0 - 800	+/- 32	+/- 2.1
O2	+/- 2%	0 - 300	+/- 6	+/- 0.61



### Opportunities to burn down risks:

1. TBD?

### Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Fire Protection Technology Demonstration Plan

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- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
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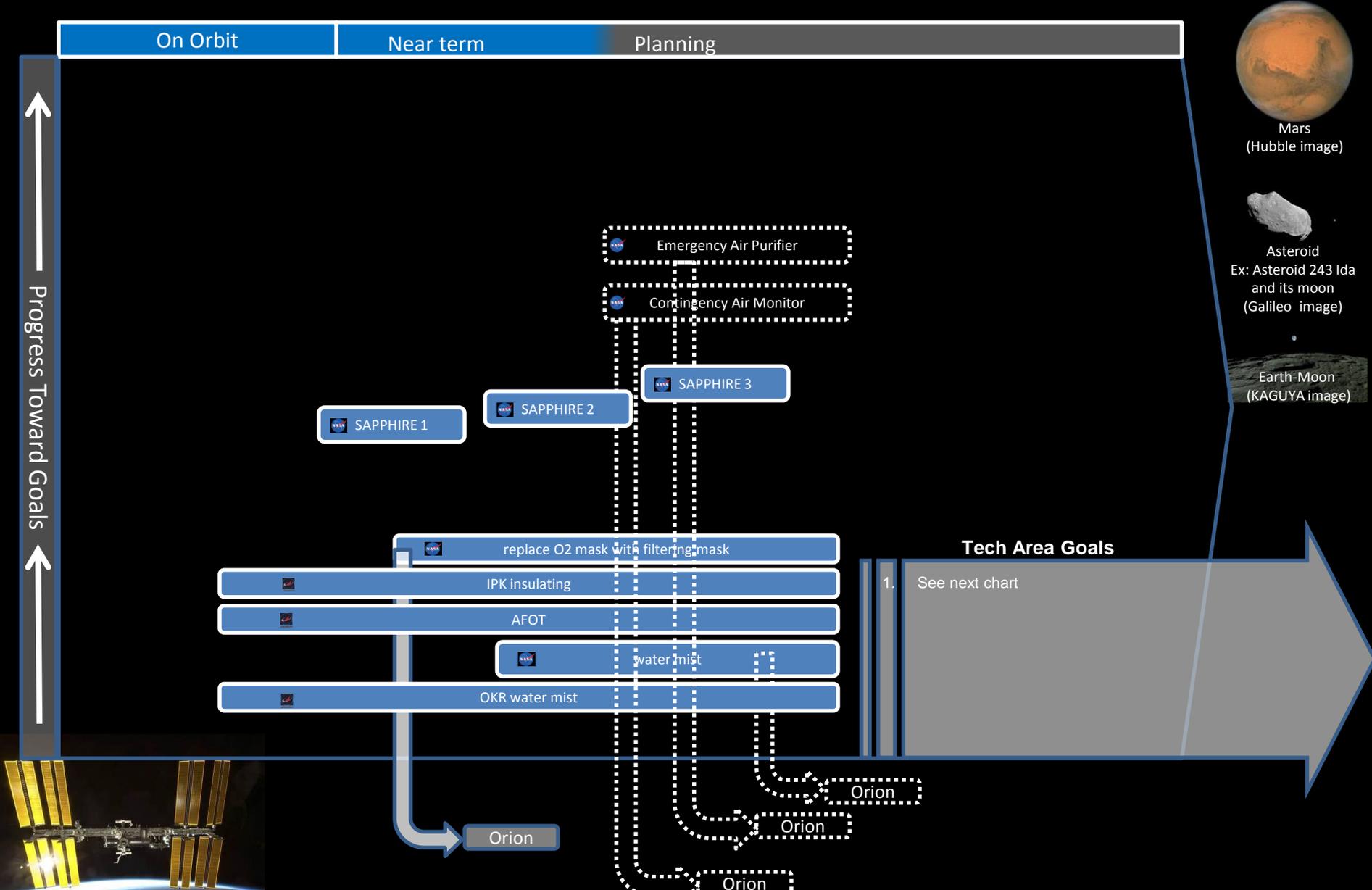
MRICB - ISS manifest

Fire Protection SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Hiroyuki Shimamura	Gary Ruff (L)	
			David Urban	
			Daniel Dietrich	
			Jon Graf	
			Mike Pedley	
			Harold Beeson	
			Richard Hill	
			Gary Ruff (L)	



# ISS Fire Protection Technology Demonstration Plan



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Fire Protection Technology Demonstration Plan

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Radiation Technology Demonstration Plan

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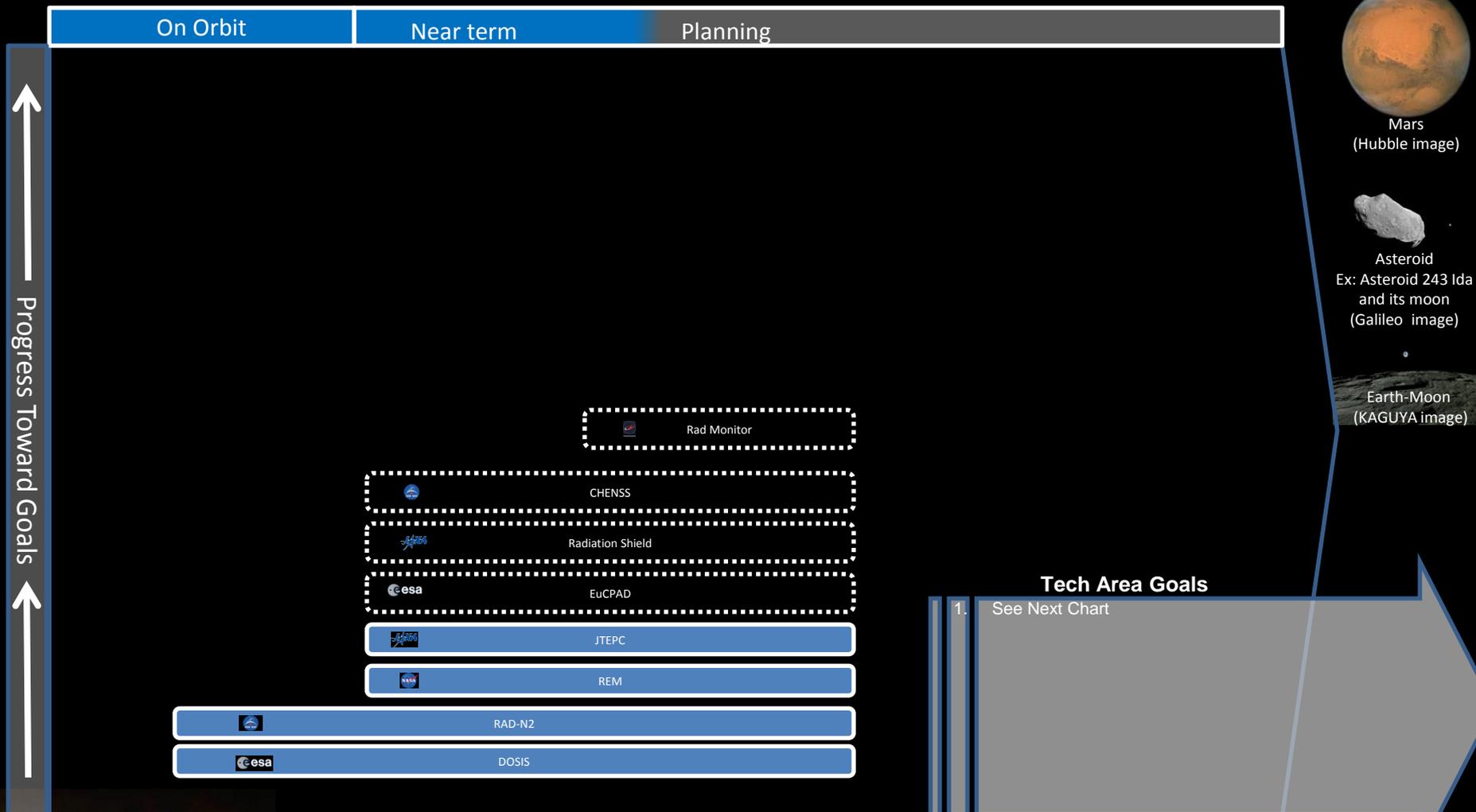
MRICB - ISS manifest

Radiation SMT

CSA	ESA	JAXA	NASA	RSA
Christian Lange	Alessandro Bergamasco	Aiko Nagamatsu	Dave Francisco (L)	
Leena Tomi	Juergen Hill (DLR)			
	Guenther Reitz (DLR)			



# ISS Radiation Technology Demonstration Plan



Planned and Funded
Proposed but NOT Funded
Ground Activities

# ISS Radiation Technology Demonstration Plan

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Crew Health/Performance Techn' Demo' Plan

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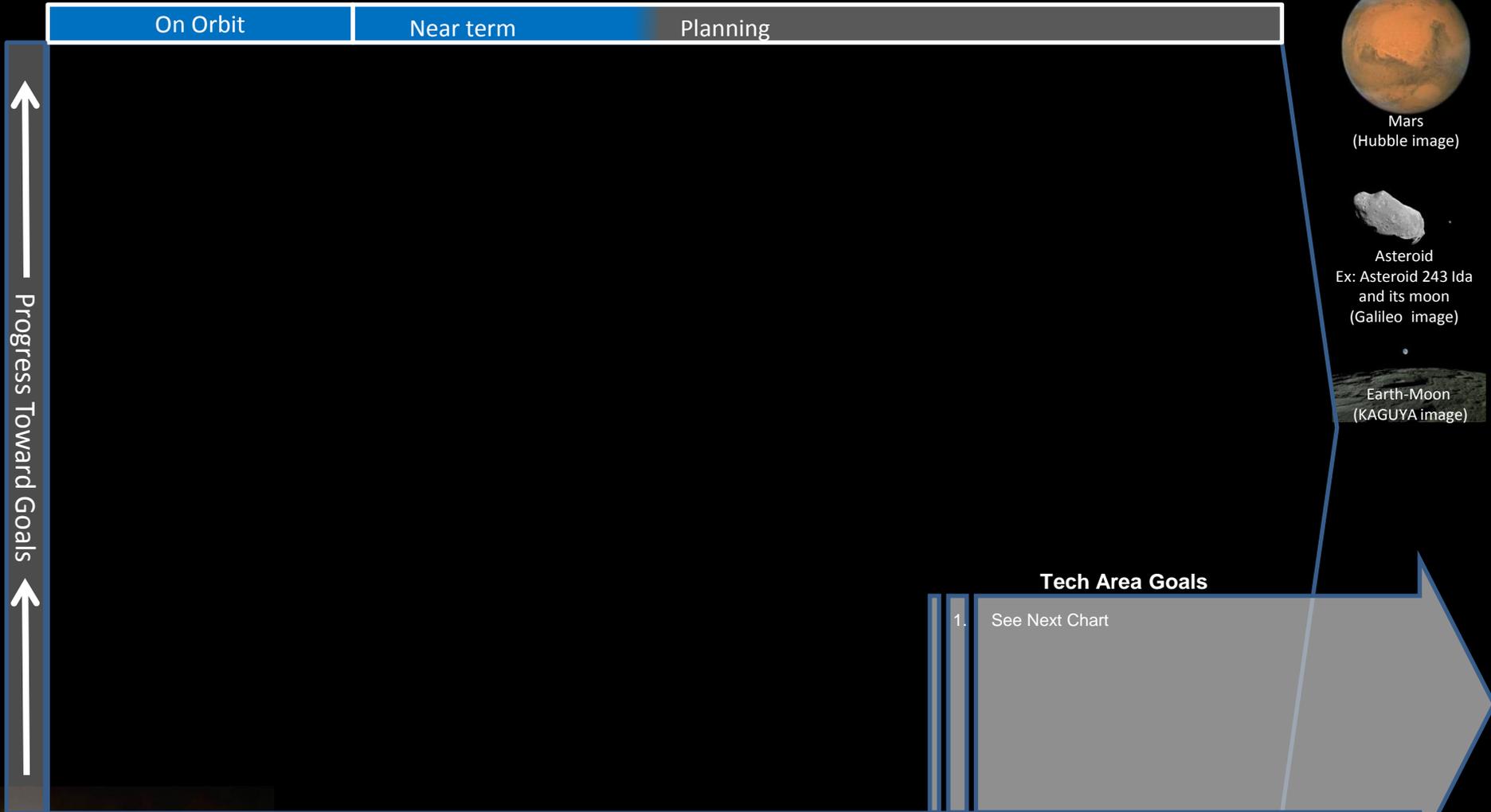
MRICB - ISS manifest

Crew Health/Performance SMT

CSA	ESA	JAXA	NASA	RSA
Christian Lange	Alessandro Bergamasco	Satoshi Furukawa	Craig Kundrot (L)	Alexey Lushin (Roscosmos)
Pat Sullivan	Alain Maillet (CNES)		Dianne Koons	
Leena Tomi	Juergen Hill (DLR)		Lisa Stephenson	
	Joern Rittweger (DLR)			



# ISS Crew Health/Performance Tech' Demo' Plan



Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Crew Health/Performance Tech' Demo' Plan

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Power and Energy Technology Demonstration Plan



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- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
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MRICB - ISS manifest

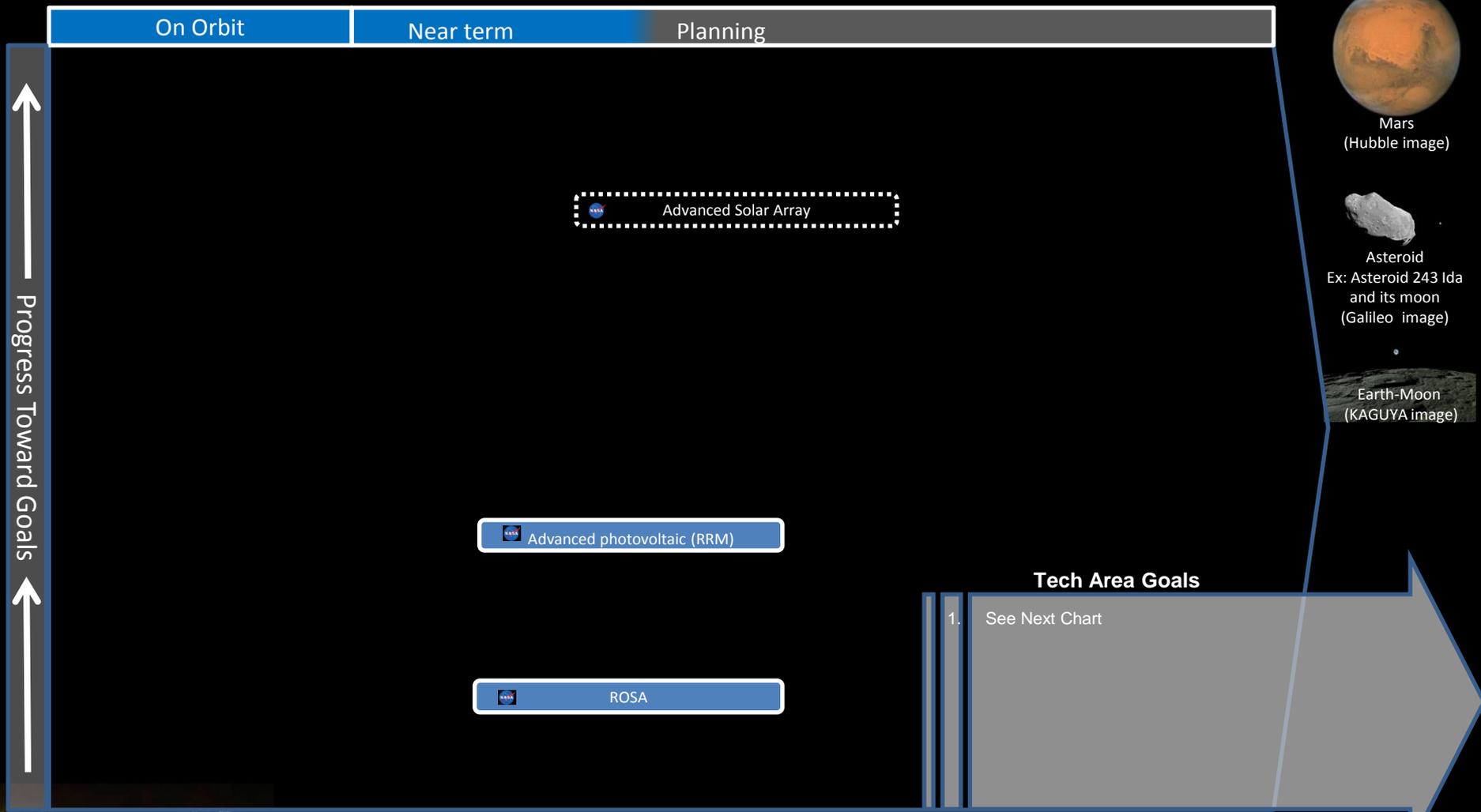
Power and Energy SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Masayuki Goto	James Soeder (L)	
	Frederic Masson (CNES)	Takeshi Hoshino	Tim Lawrence	
			Tony Clark	
			Dave Hoffman	
			Ray Beach	



# ISS Power and Energy Technology Demonstration Plan

## Power Generation



Planned and Funded
Proposed but NOT Funded
Ground Activities



# ISS Power and Energy Technology Demonstration Plan

## Power Generation

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

- 1. TBD?

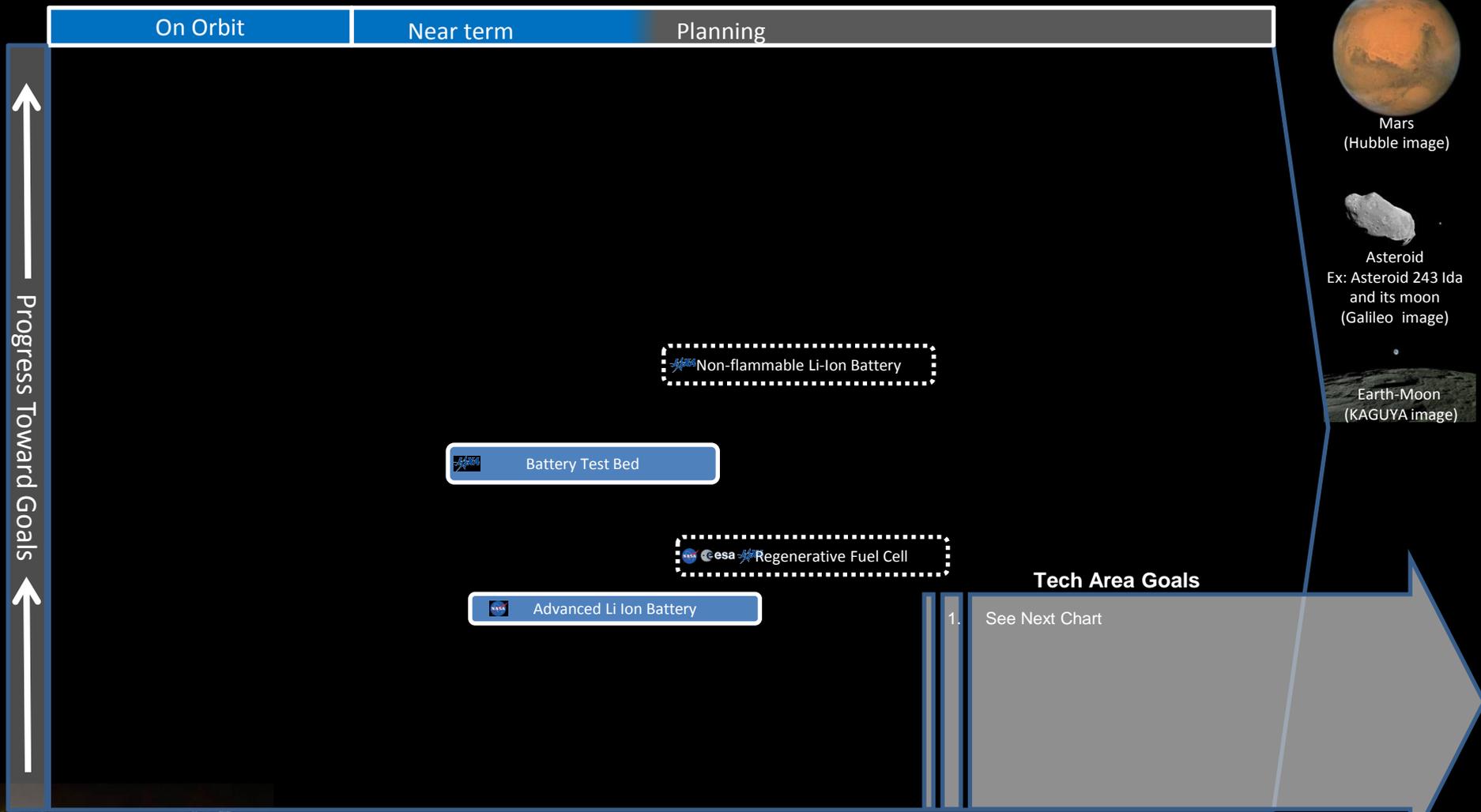
Dependencies / Standards / Decisions needed:

- 1. TBD?



# ISS Power and Energy Technology Demonstration Plan

## Energy Storage



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Power and Energy Technology Demonstration Plan

## Energy Storage

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

- 1. TBD?

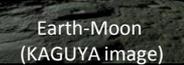
Dependencies / Standards / Decisions needed:

- 1. TBD?



# ISS Robotics and Autonomy Technology Demonstration Plan

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- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
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MRICB - ISS manifest

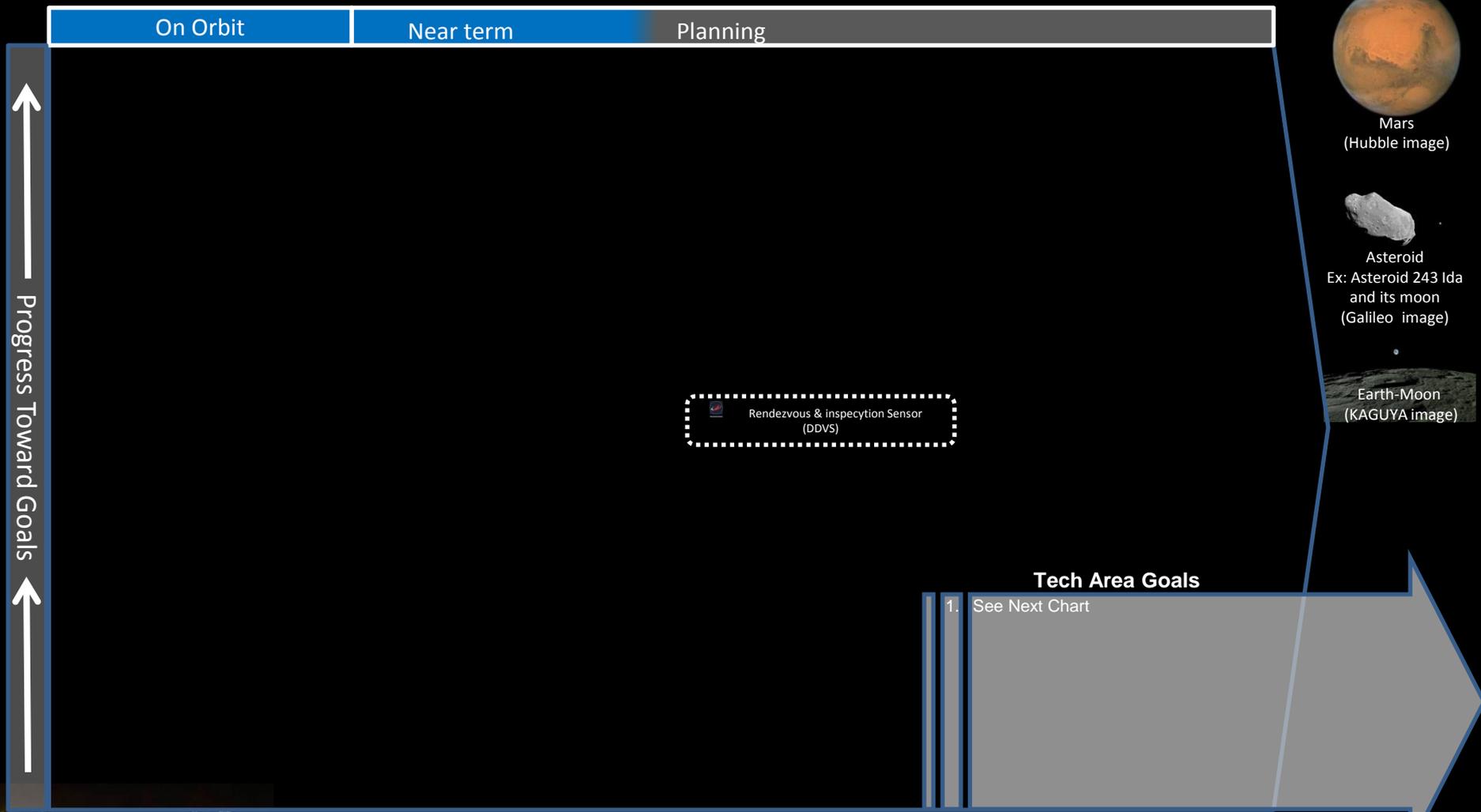
Robotics and Autonomy SMT

CSA	ESA	JAXA	NASA	RSA
Christian Lange	Alessandro Bergamasco	Hitoshi Morimoto	Rob Ambrose	
Eric Martin	Philippe Schoonejans	Tomoya Suehiro	Phil Callen	
Michel Wander	Juergen Hill (DLR)	Sachiko Wakabayashi	Bill Bluethmann	
	Bernd Schäfer (DLR)		Brian Wilcox	
			Terry Fong	
			Rob Mueller	
			Ben Reed	



# ISS Robotics and Autonomy Technology Demonstration Plan

## Sensing and Perception



Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Robotics and Autonomy Technology Demonstration Plan

## Sensing and Perception

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

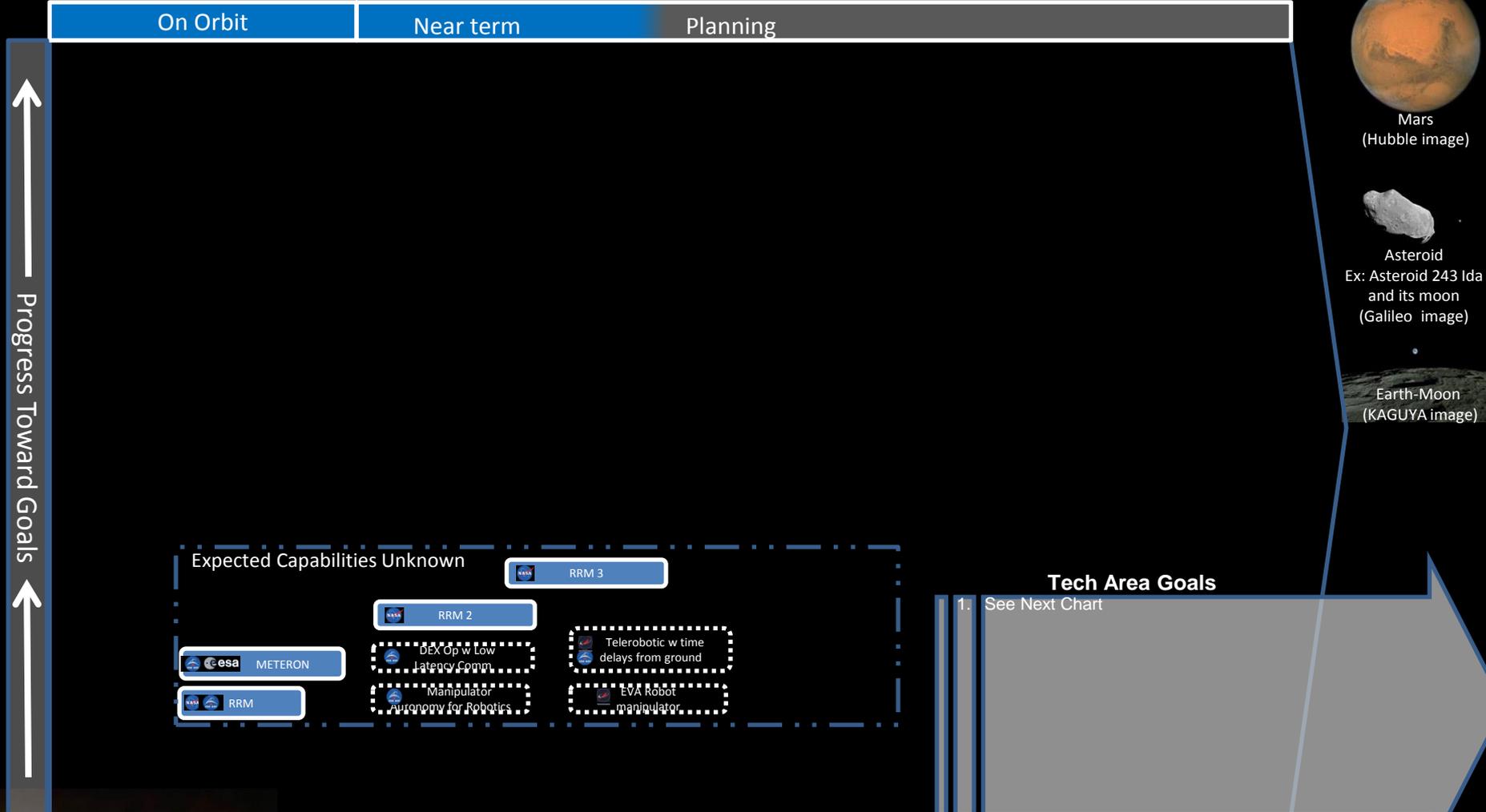
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Robotics and Autonomy Technology Demonstration Plan

## Mobility / Manipulation



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Robotics and Autonomy Technology Demonstration Plan

## Mobility / Manipulation

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

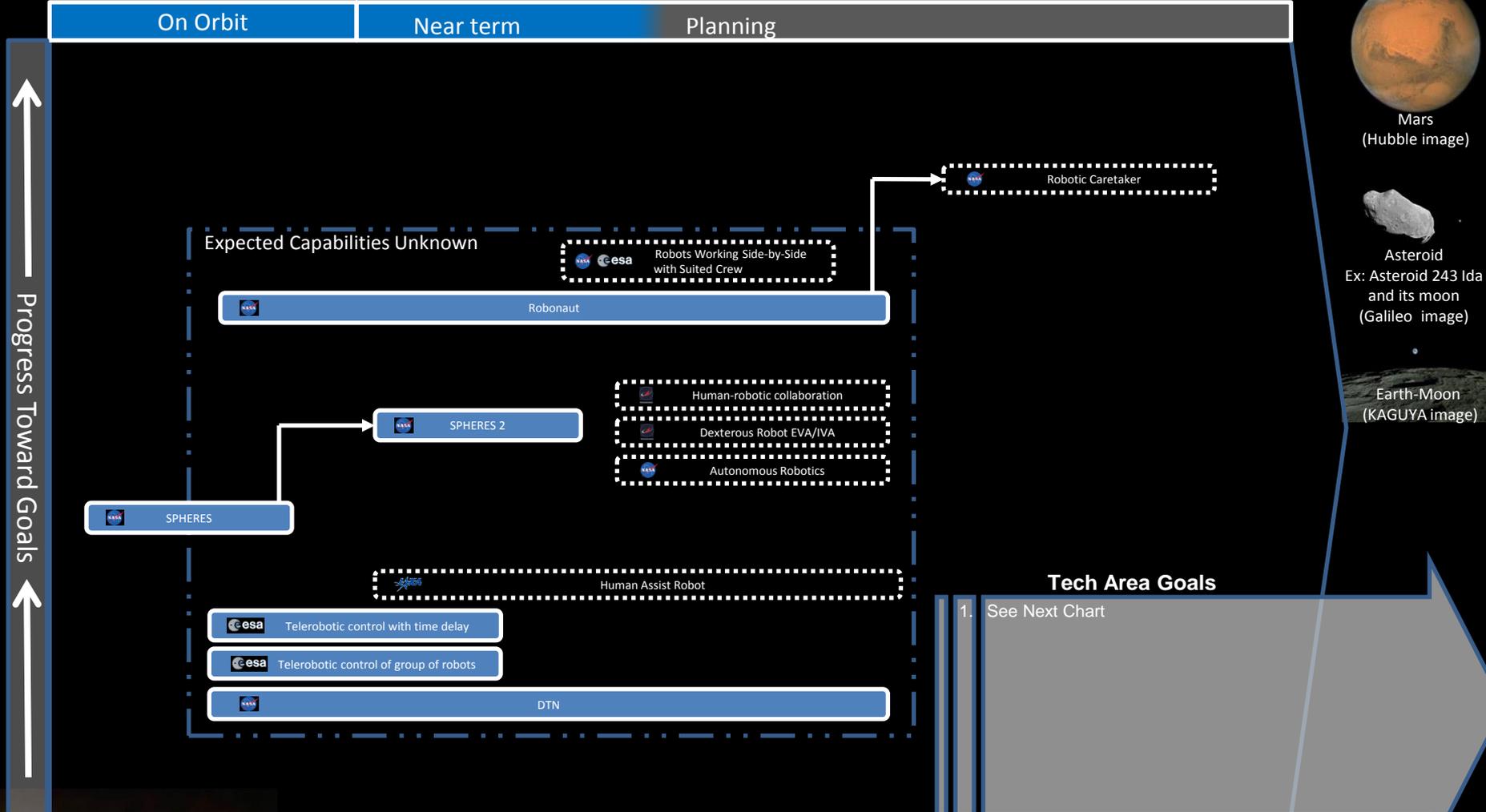
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Robotics and Autonomy Technology Demonstration Plan

## Human-Systems Integration / Autonomy



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Robotics and Autonomy Technology Demonstration Plan

## Human-Systems Integration / Autonomy

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

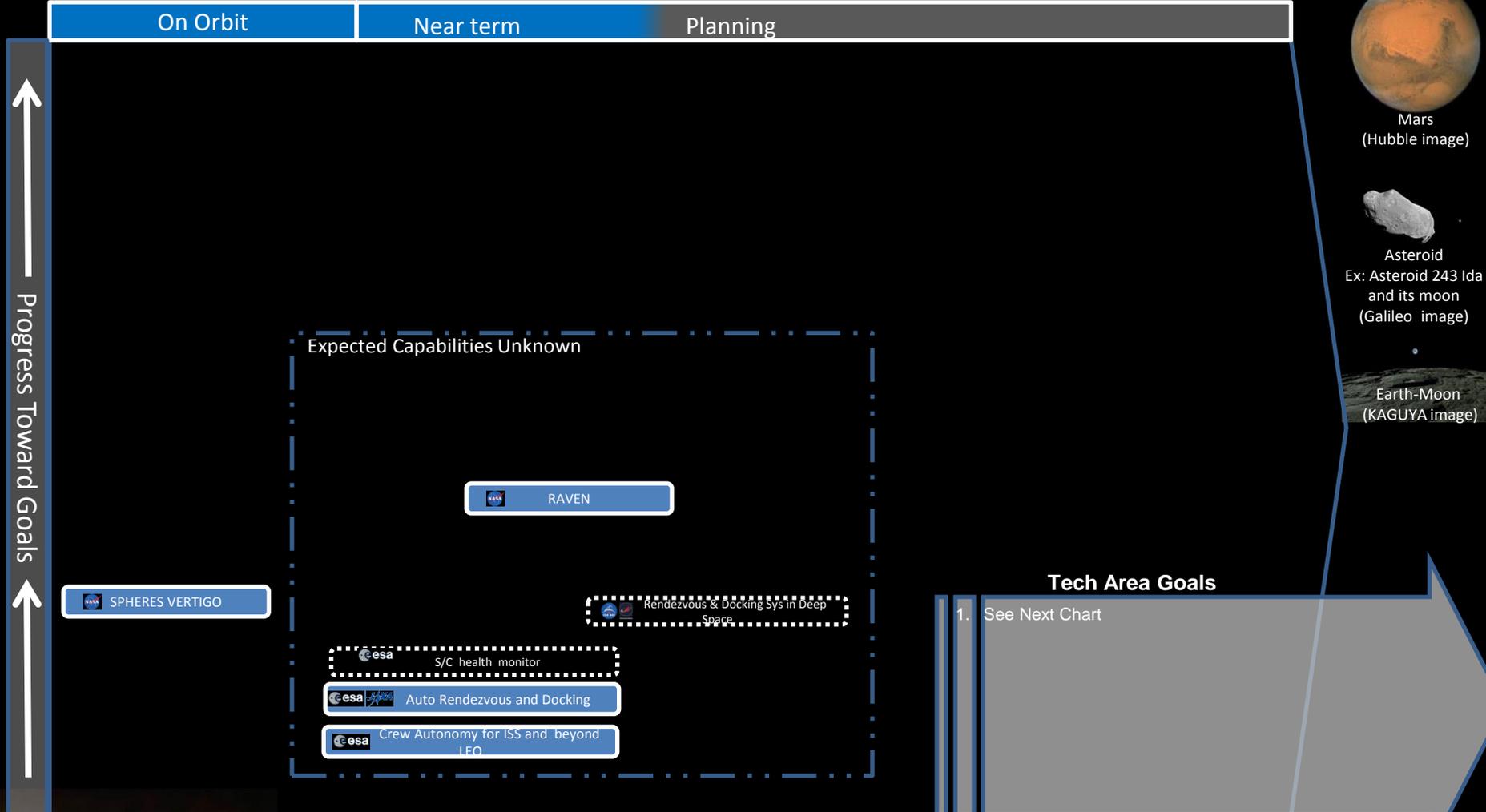
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Robotics and Autonomy Technology Demonstration Plan

## Autonomous, Rendezvous/ Docking



Planned and Funded | Proposed but NOT Funded | Ground Activities

# ISS Robotics and Autonomy Technology Demonstration Plan

Autonomous, Rendezvous/ Docking

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



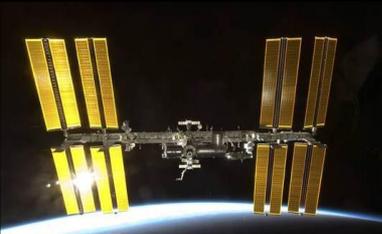
Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Comm and Nav Technology Demonstration Plan

- ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG
- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
  - **Current Revision can be found at:** <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>



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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
<https://www.globalspaceexploration.org/>

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Comm and Nav SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Koji Yamanaka	Marc Seibert	
	Diego De Rosa			
	Berengere Houdou			



# ISS Comm and Nav Technology Demonstration Plan

## Communication / Internetworking



Planned and Funded    Proposed but NOT Funded    Ground Activities

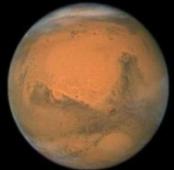


# ISS Comm and Nav Technology Demonstration Plan

Communication / Internetworking

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

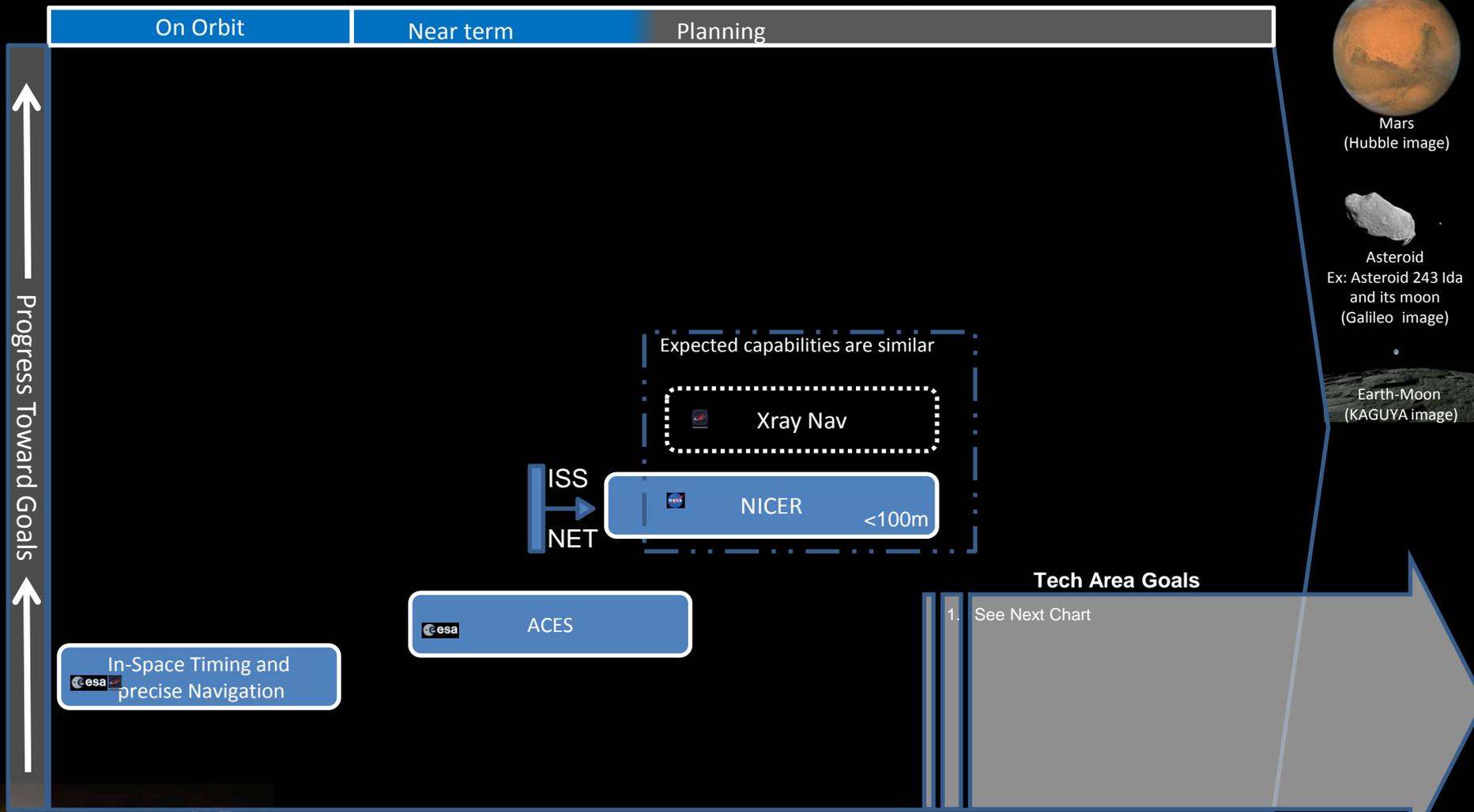
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Comm and Nav Technology Demonstration Plan

## Position, Navigation and Timing



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Comm and Nav Technology Demonstration Plan

Position, Navigation and Timing

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

- 1. TBD?

Dependencies / Standards / Decisions needed:

- 1. TBD?



# ISS Operations Technology Demonstration Plan

ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA) Current Revision can be found at: <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>



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Technology Area Goals based on the Global Exploration Roadmap (GER).

<https://www.globalspaceexploration.org/>



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Autonomous Mission  
Operations SMT

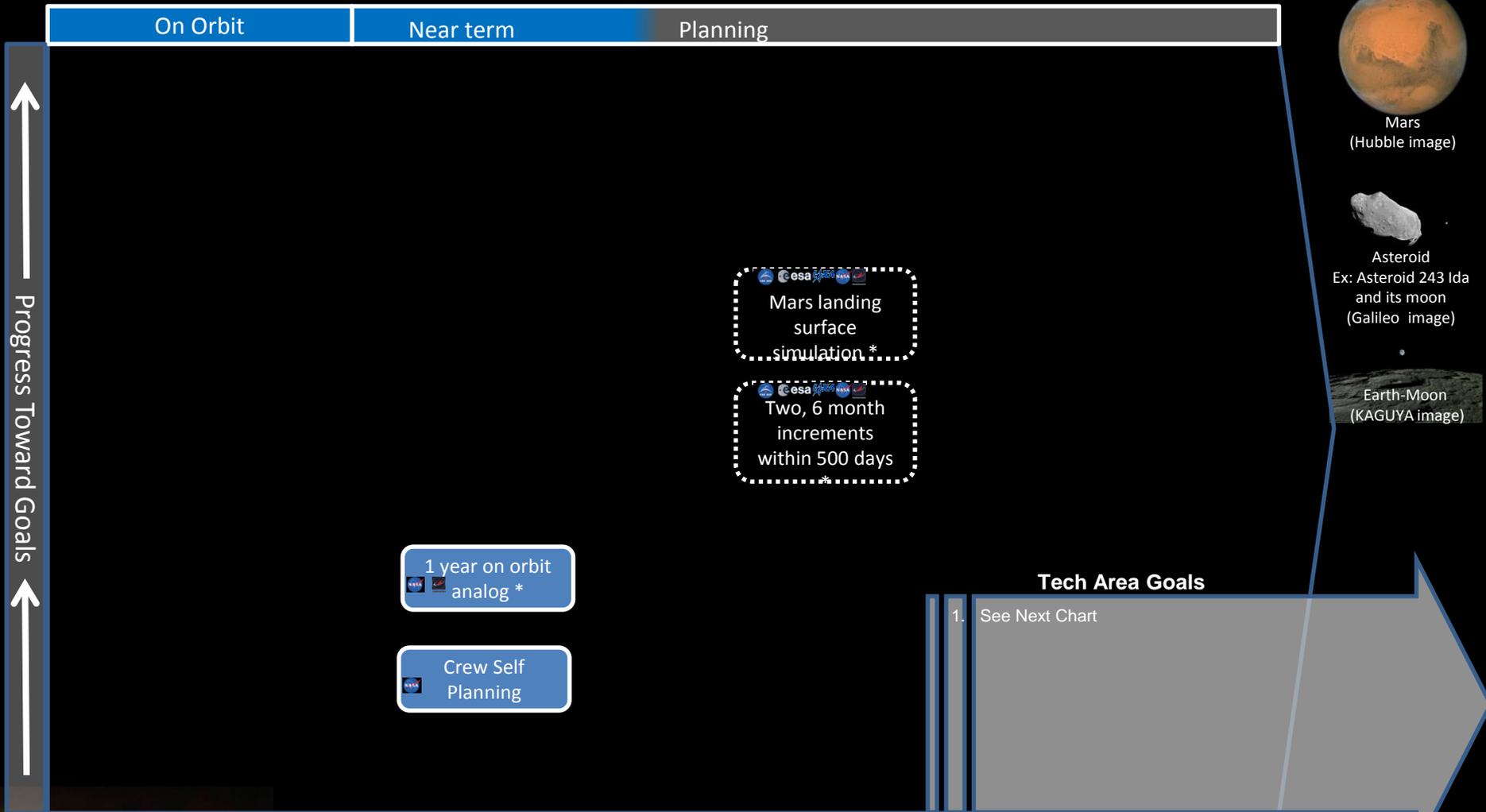


CSA	ESA	JAXA	NASA	RSA
Yves Gonthier	Alessandro Bergamasco	Takayoshi Nishikawa	Jeremy Frank (L)	
André Jodoin	Matthias Maurer		David Korth	
Christian Lange	Mikael Wolff		Bill Spetch	
Edward Tabarah	Jean-Paul Berthias (CNES)		L Morin	
	Juergen Hill (DLR)		M Lowry	
			R McCann	
			D Alfano	
			A Stroupe	
			S Love	



# ISS Operations Technology Demonstration Plan

## Flight Crew Analogs



Planned and Funded | Proposed but NOT Funded | Ground Activities

# ISS Operations Technology Demonstration Plan

Flight Crew Analogs

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

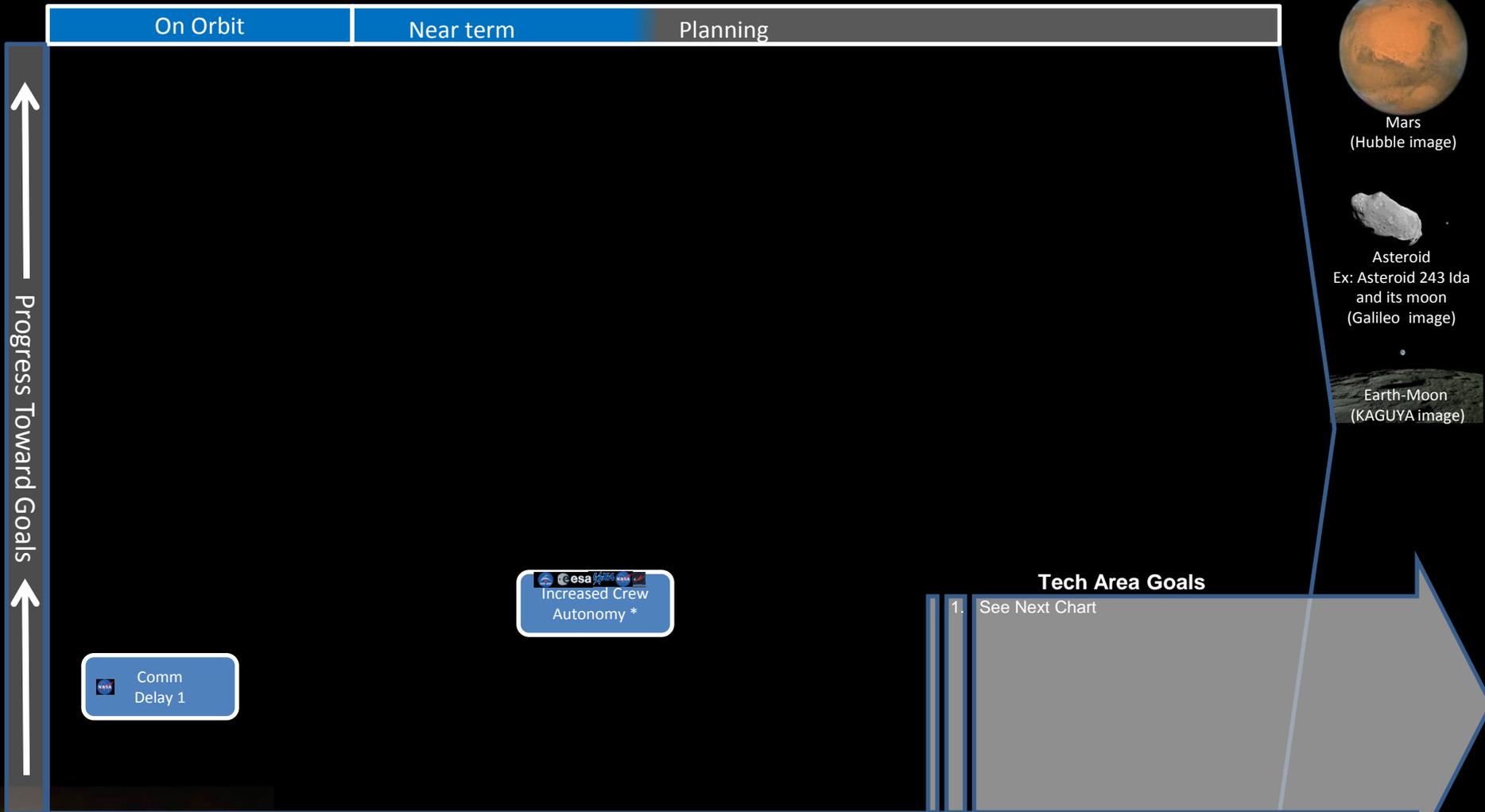
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Operations Technology Demonstration Plan

## Air-to-ground Comm Sims



Planned and Funded      Proposed but NOT Funded      Ground Activities

# ISS Operations Technology Demonstration Plan

Air-to-ground Comm Sims

Technical Goals:

TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Thermal Management Technology Demonstration Plan



ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG

- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
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<https://www.globalspaceexploration.org/>

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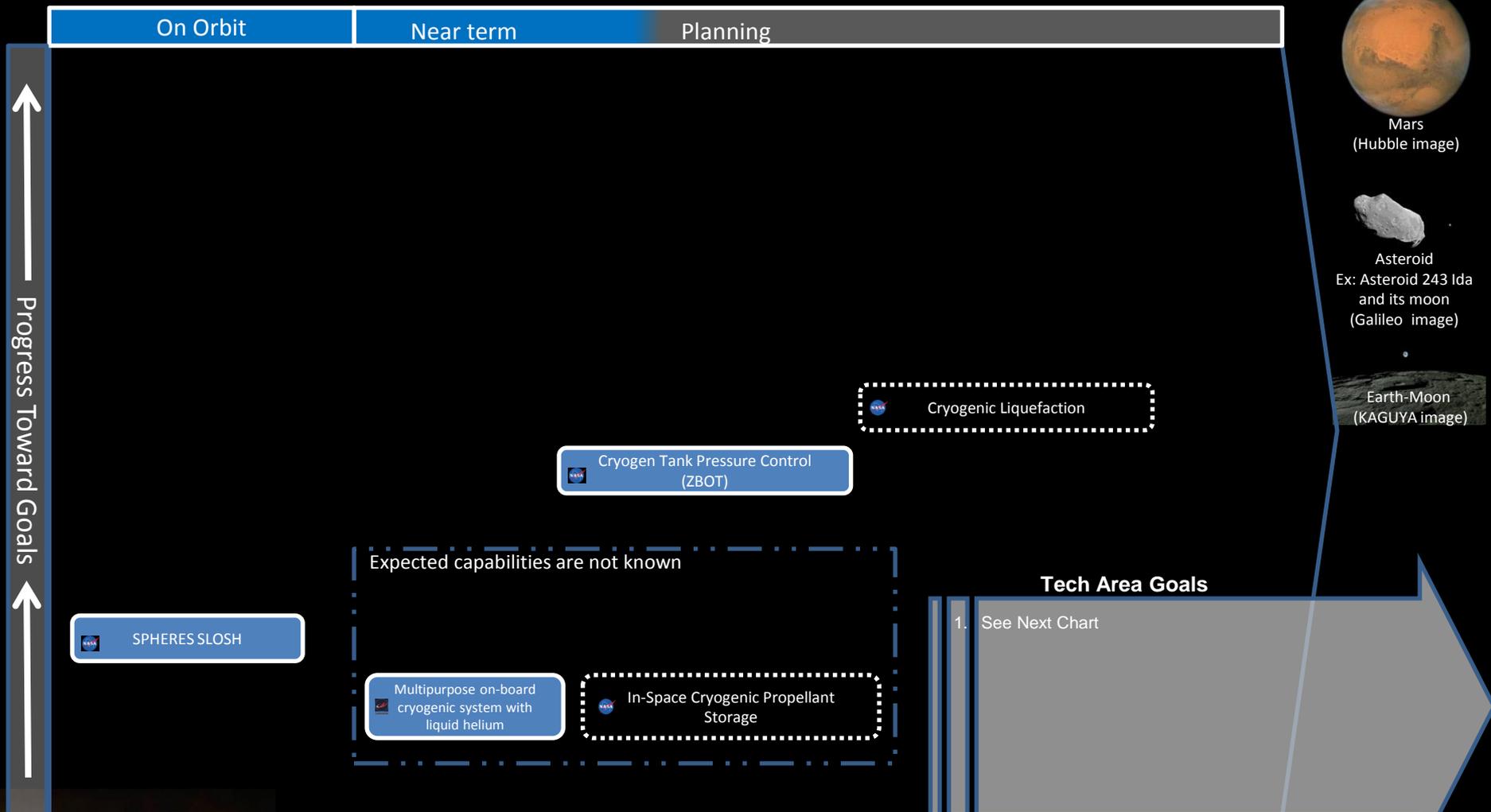
Thermal Management SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Kiyoshi Kinefuchi	Craig Dinsmore	
	Vincent Leudiere (CNES)	Tomomi Suzuki	Richard Morton	
			Brian Motil	
			Ryan Stephan	
			Ron Lewis	
			Howard Wagner	



# ISS Thermal Management Technology Demonstration Plan

## Cryogenic Systems



Planned and Funded      Proposed but NOT Funded      Ground Activities



# ISS Thermal Management Technology Demonstration Plan

## Cryogenic Systems

### Technical Goals:

- Cryo-cooling for Zero boil-off cryogenic storage and handling
- Liquid-vapor separation and liquid acquisition
- Tank pressure control
- RF and acoustic mass gauging
- Reusable In-Space Cryogenic Disconnects
- Low-conductivity structure and insulations



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

### Opportunities to burn down risks:

1. TBD?

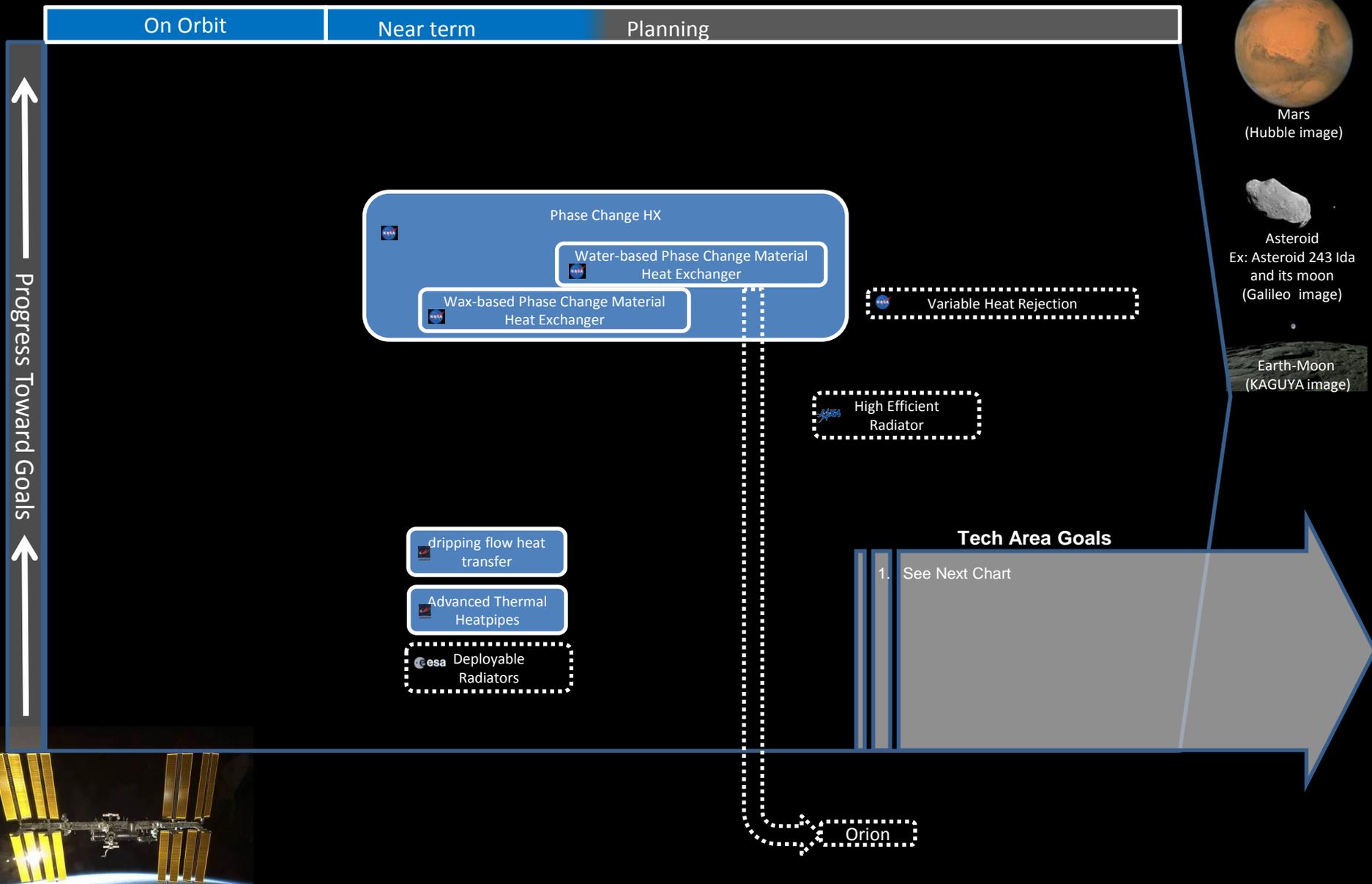
### Dependencies / Standards / Decisions needed:

1. Fuel to be stored is Methane or Hydrogen?



# ISS Thermal Management Technology Demonstration Plan

## Thermal Control Systems



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Thermal Management Technology Demonstration Plan

## Thermal Control Systems

### Technical Goals:

- Low-mass heat rejection “topping” capability for cyclic thermal environments
- Contamination-insensitive heat rejection for space suit systems
- Two-phase fluids management (provide microgravity phase separation)
- Active thermal control “turn-down” capability for missions with high variability in thermal environments and heat loads
- Lightweight-efficient heat exchangers and cold plates
- Low-toxicity, high-performance thermal transport fluids (enables single-loop)
- Human thermal modeling and system integration capability
- In-space radiator repair (increase from limited connectors/fluid lines)
- Multi-layer insulation with reduced effective emissivity
- Advanced heat straps and thermal switches
- Low-conductivity structure



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

### Opportunities to burn down risks:

1. TBD?

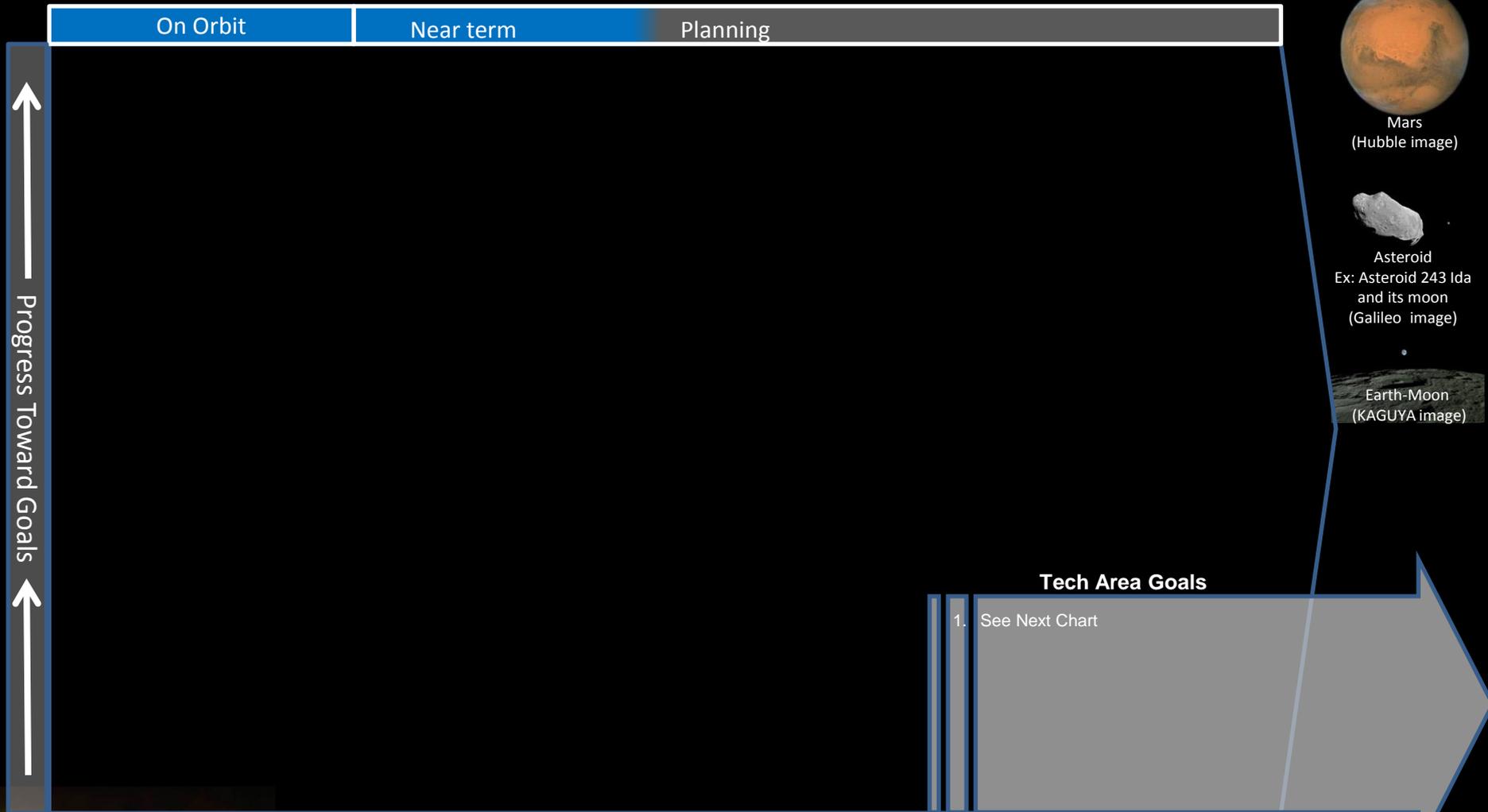
### Dependencies / Standards / Decisions needed:

1. Tbd?



# ISS Thermal Management Technology Demonstration Plan

## Thermal Protection Systems



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Thermal Management Technology Demonstration Plan

## Thermal Protection Systems

### Technical Goals:

- TPS for high-energy Earth re-entry (>11.5 km/sec) to address current material limitations and obsolescence issues
- High-temperature ablative materials
- Flexible, low-thermal conductivity materials for use on rigid or deployable systems enabling lower heat flux and higher ballistic coefficient while packaging in existing shrouds
- In-space TPS repair with increased capability beyond STA-54 developed for shuttle tile repair
- TPS Test Facilities/Techniques
- High temperature blankets
- Material response models for new materials



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

### Opportunities to burn down risks:

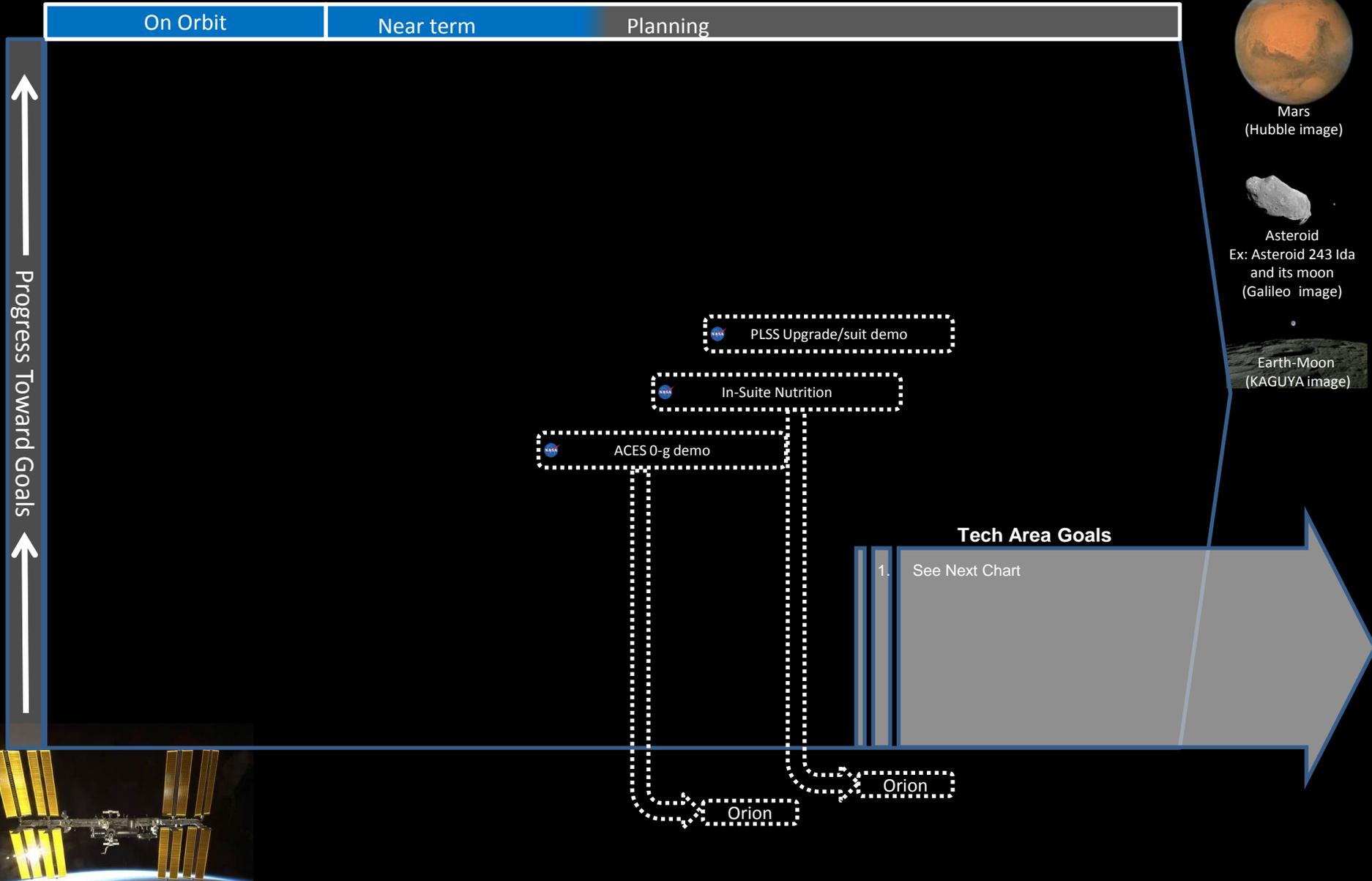
1. TBD?

### Dependencies / Standards / Decisions needed:

1. Fuel to be stored is Methane or Hydrogen?



# ISS EVA Technology Demonstration Plan



Planned and Funded      Proposed but NOT Funded      Ground Activities

# ISS EVA Technology Demonstration Plan

## Technical Goals:

- TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

## Opportunities to burn down risks:

1. TBD?

## Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Entry, Descent Technology Demonstration Plan

ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG

- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emelyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
- Current Revision can be found at: <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>



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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
<https://www.globalspaceexploration.org/>



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Entry Descent and Landing SMT

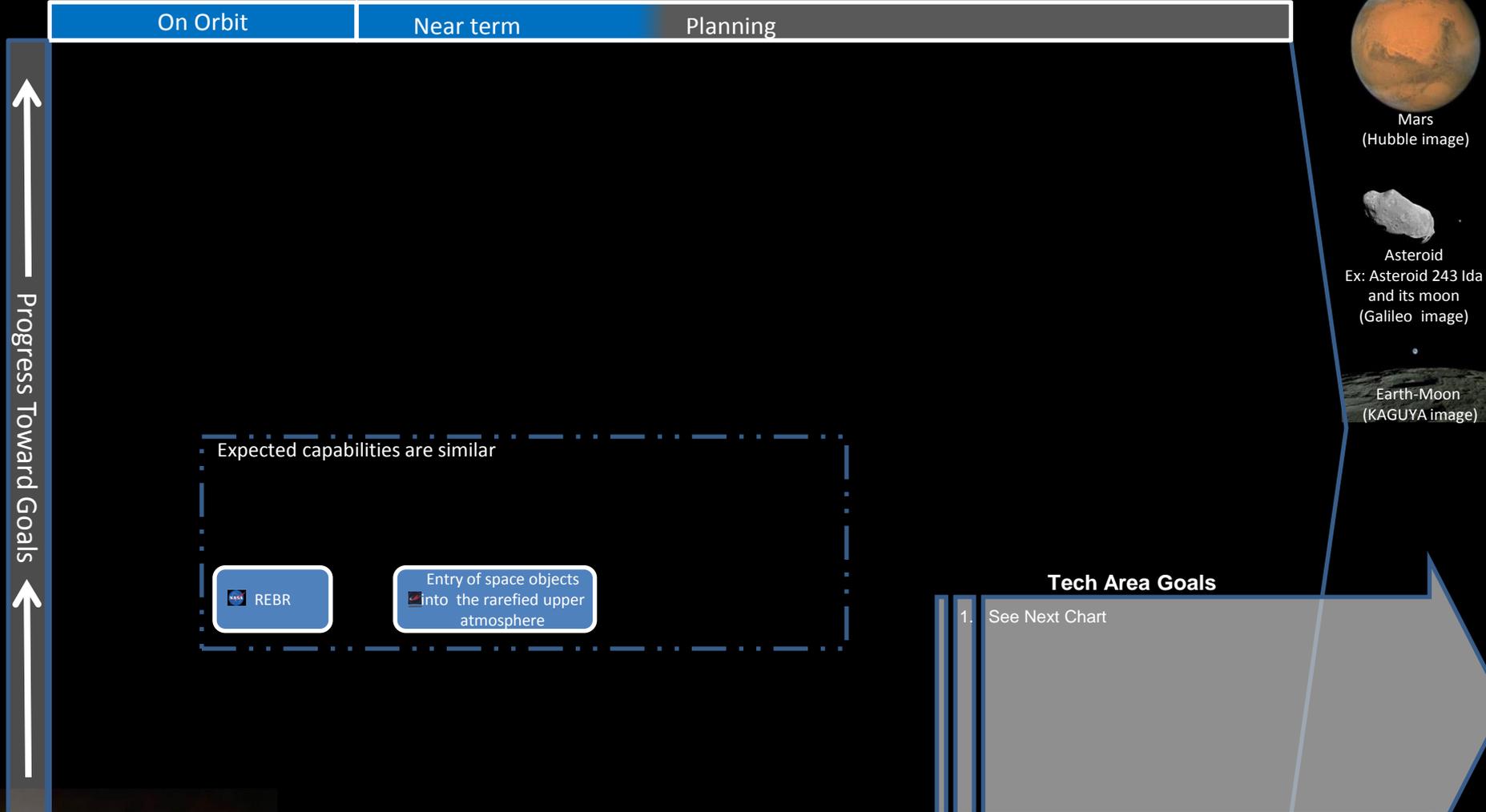


CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Tatsuaki Hashimoto	Michelle Munk	
	Pierre Omalý (CNES)			



# ISS Entry, Descent Technology Demonstration Plan

Instrumentation and knowledge



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Entry, Descent Technology Demonstration Plan

Instrumentation and knowledge

Technical Goals:

- TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

Opportunities to burn down risks:

1. TBD?

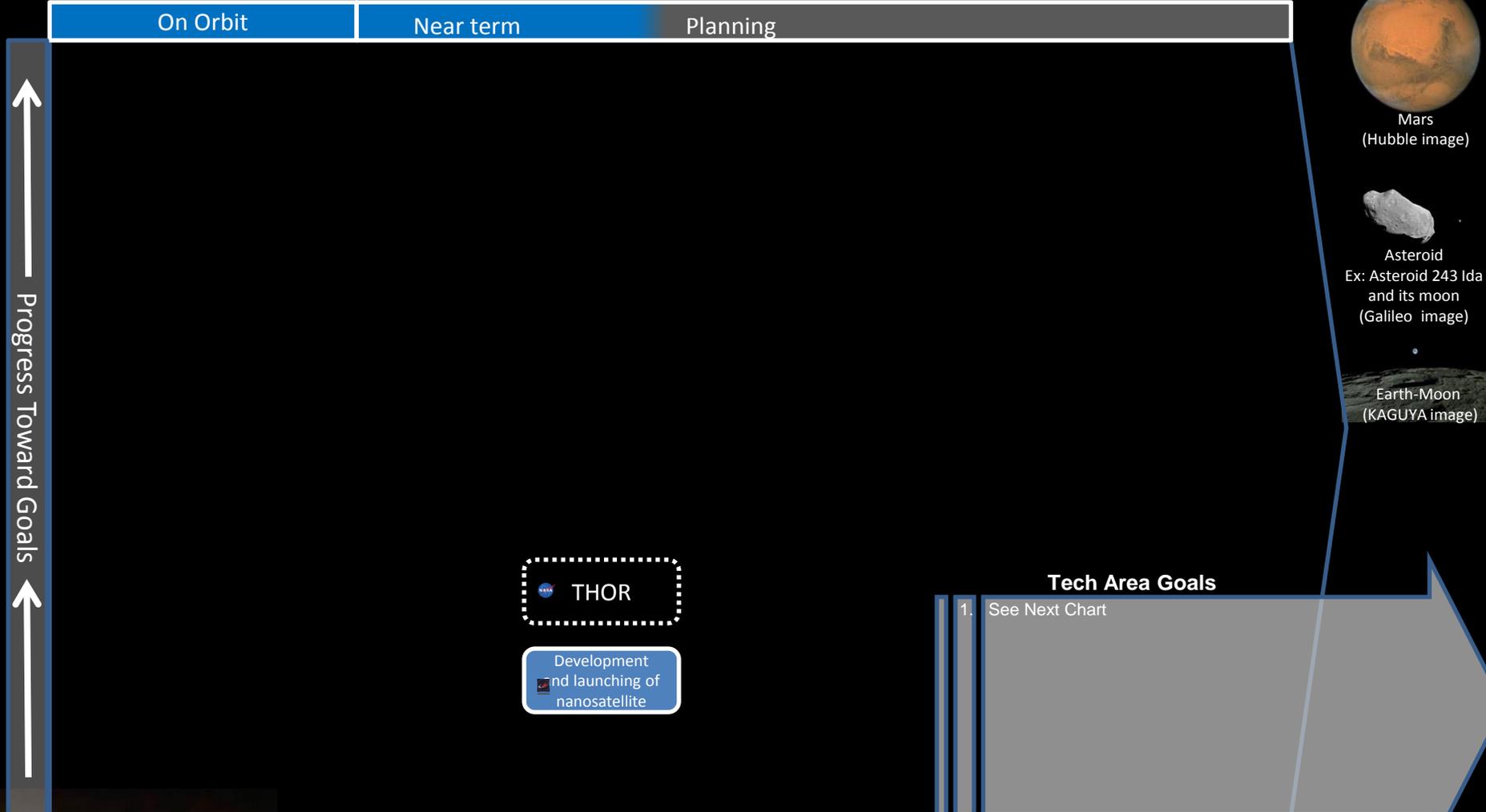
Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Entry, Descent Technology Demonstration Plan

## Aeroassist and Entry



Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Entry, Descent Technology Demonstration Plan

## Aeroassist and Entry

### Technical Goals:

- TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

### Opportunities to burn down risks:

1. TBD?

### Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Propulsion Technology Demonstration Plan

ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG

- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
- Current Revision can be found at: <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>

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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
<https://www.globalspaceexploration.org/>



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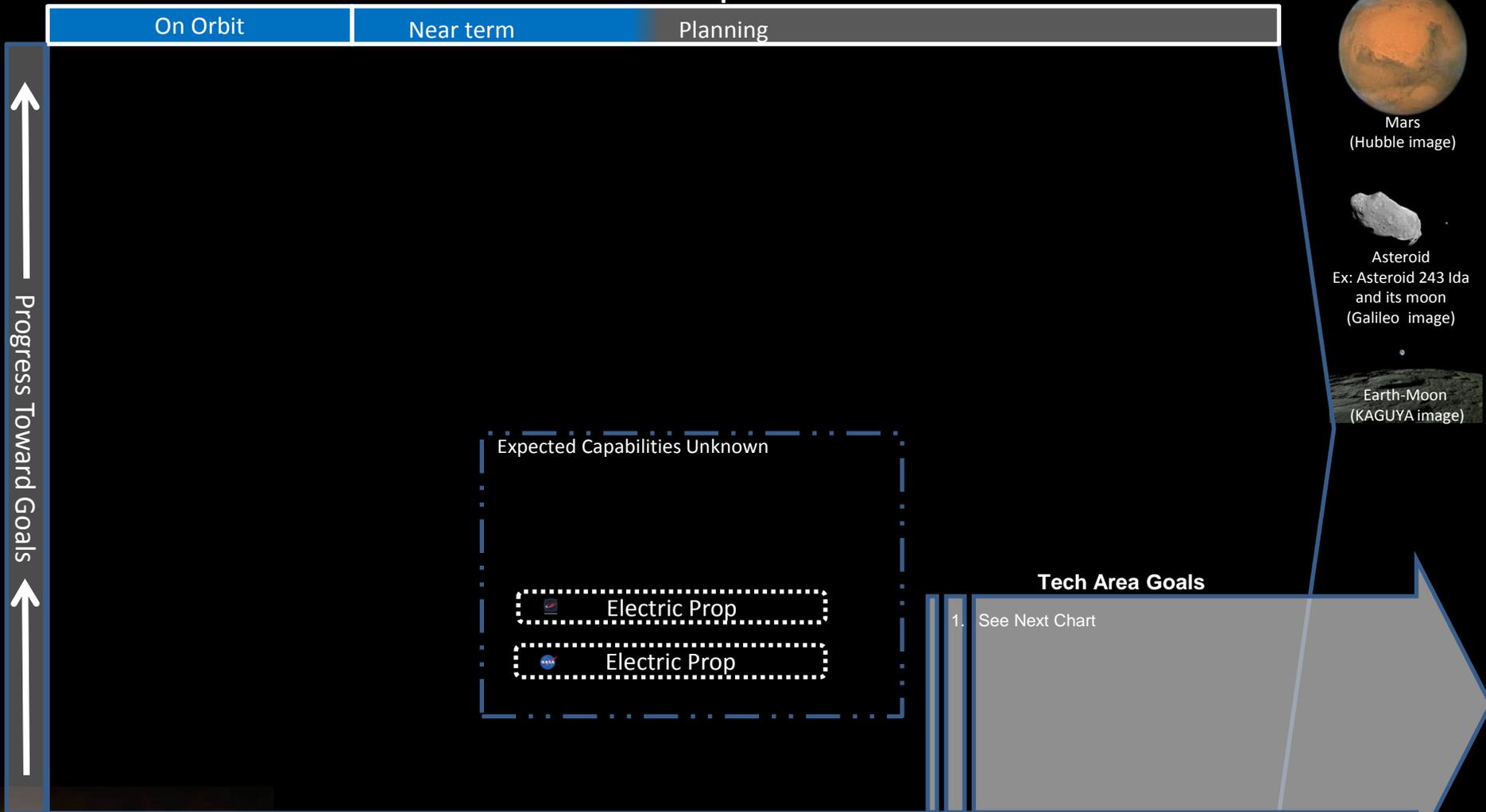
In-space Propulsion SMT

CSA	ESA	JAXA	NASA	RSA
	Alessandro Bergamasco	Kiyoshi Kinefuchi	Les Johnson	
	Jean-Marc Ruault (CNES)	Shintaro Nishihira	Leslie Alexander	
			John Applewhite	
			Sonny White	
			Chuck Taylor	
			David Jacobson	
			Dave Manzella	
			Harold Gerrish	
			John Warren	



# ISS Propulsion Technology Demonstration Plan

## Electric Propulsion



Planned and Funded    Proposed but NOT Funded    Ground Activities

# ISS Propulsion Technology Demonstration Plan

## Electric Propulsion

### Technical Goals:

- TBD



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

### Opportunities to burn down risks:

1. TBD?

### Dependencies / Standards / Decisions needed:

1. TBD?



# ISS Destination Systems Technology Demonstration Plan

ISS Technology Demonstration Program is compiled and maintained by the Tech and Ops WG

- Christian Lange (CSA), Sylvie Espinasse (ESA), Tsuyoshi Ito (JAXA), Hiroyasu Mizuno (JAXA), George Nelson (NASA), Igor Soroki and Olga Emeldyashcheva (RSA), Andrew Clem (NASA), David Hornyak (NASA)
- **Current Revision can be found at:** <https://iss-www.jsc.nasa.gov/nwo/payload/home/web/>

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- Technology Area Goals based on the Global Exploration Roadmap (GER).  
<https://www.globalspaceexploration.org/>

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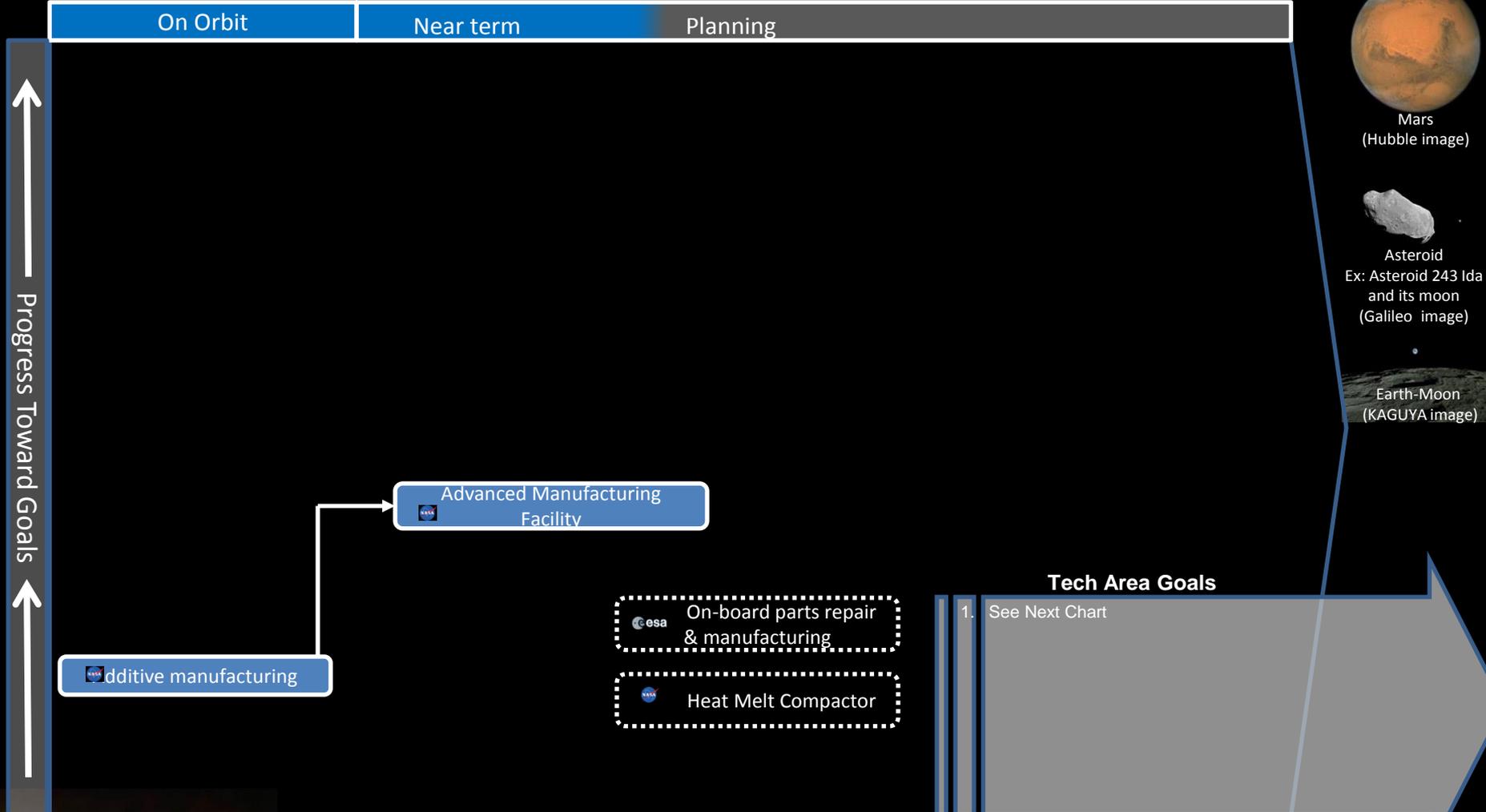
MRICB - ISS manifest

Destination Systems



# ISS Destination Systems Technology Demonstration Plan

## Sustainability & Supportability

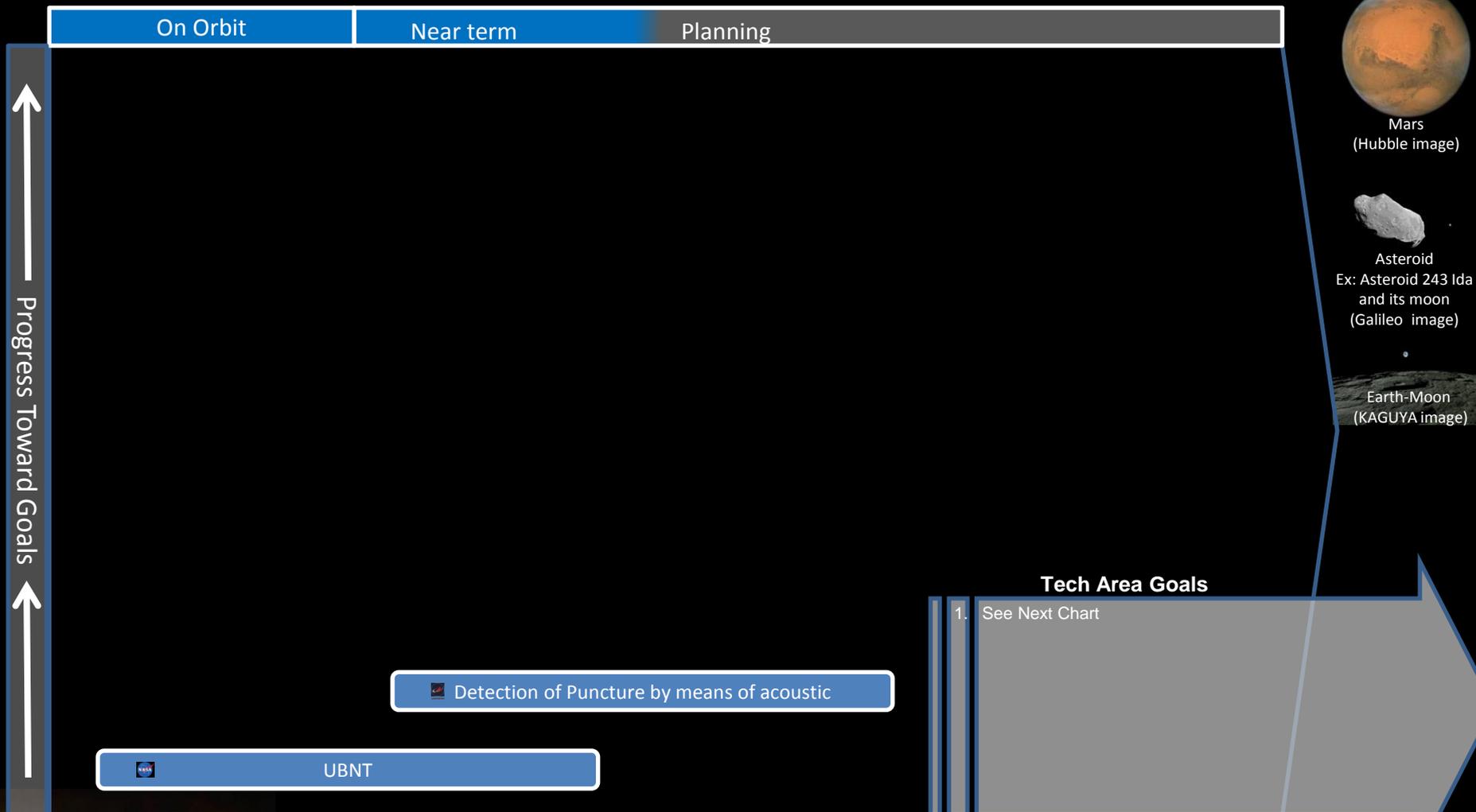


Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Destination Systems Technology Demonstration Plan

## Advanced Habitat Systems



Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Destination Systems Technology Demonstration Plan

## Sustainability & Supportability :

- Technology Area Goals need more specific definition.
- Existing proposals in Tech Area need to be compared to Tech Area Goals for progress.
- New proposal areas need to be identified if the existing demonstrations do not meet tech area goals.

## Advanced Habitat Systems :

- Technology Area Goals need more specific definition.
- Existing proposals in Tech Area need to be compared to Tech Area Goals for progress.
- New proposal areas need to be identified if the existing demonstrations do not meet tech area goals.



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



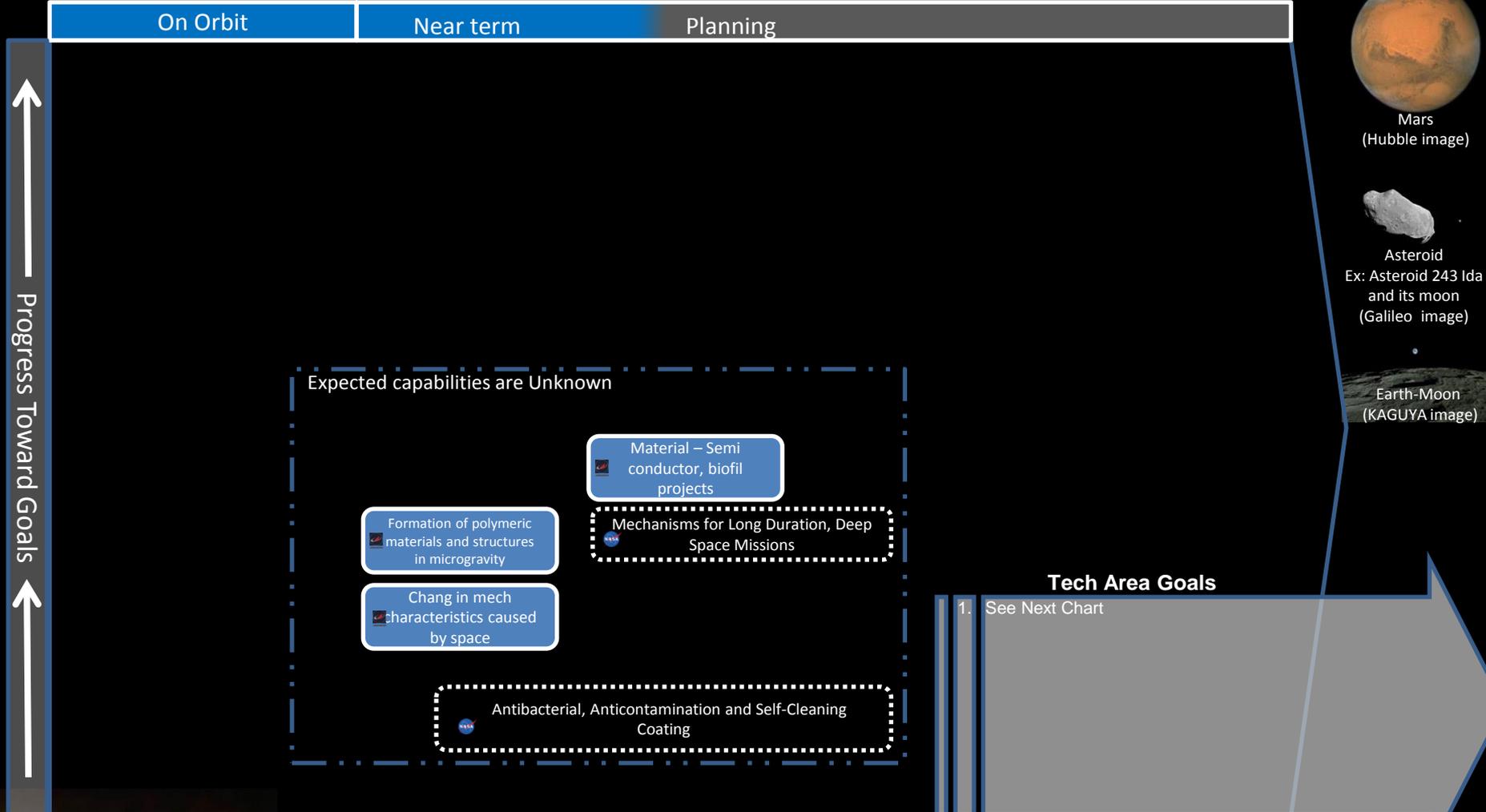
Earth-Moon  
(KAGUYA image)





# ISS Struc and Mech Technology Demonstration Plan

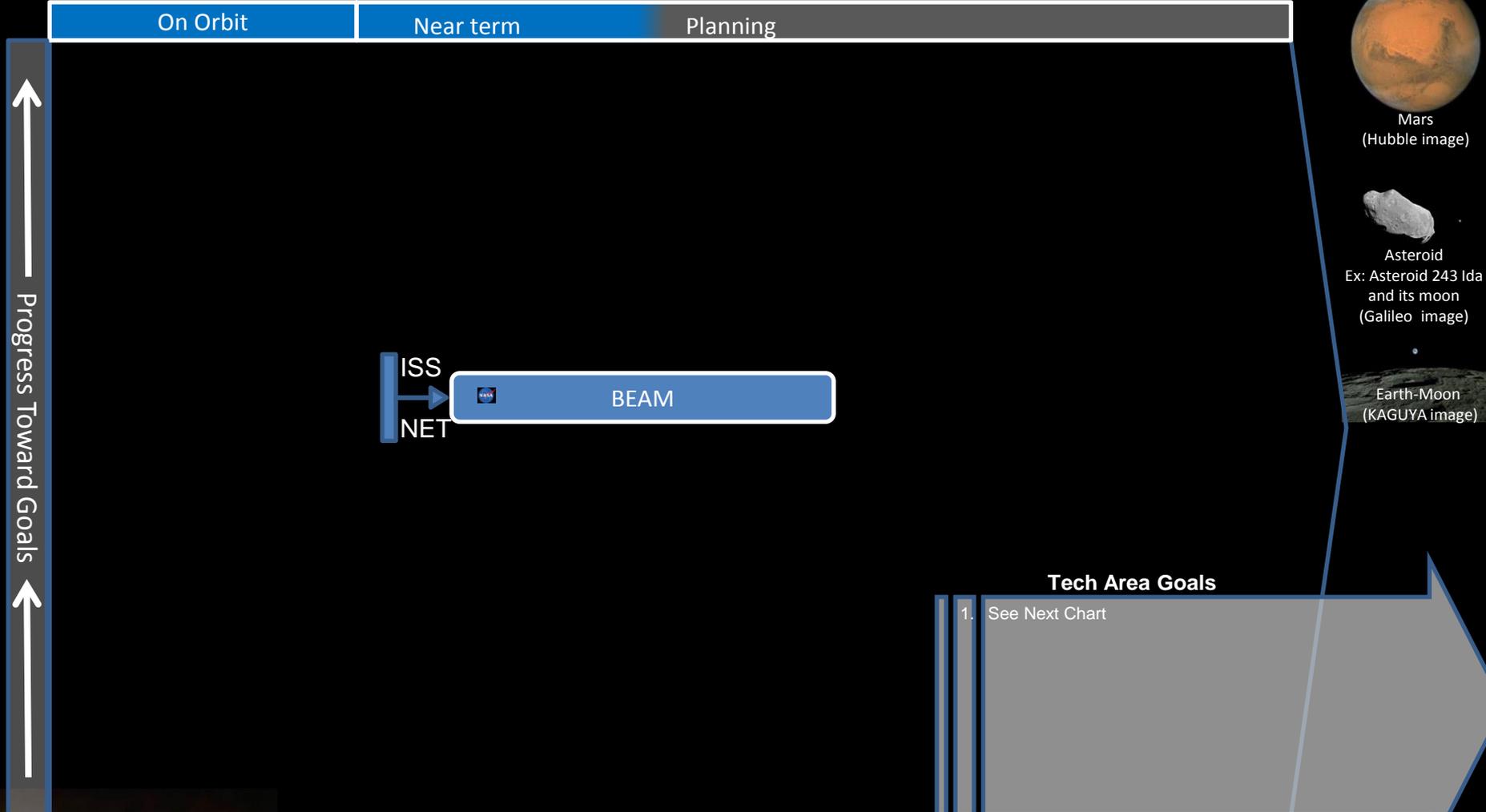
## Materials, Mechanisms



Planned and Funded | Proposed but NOT Funded | Ground Activities

# ISS Struc and Mech Technology Demonstration Plan

## Structures



Planned and Funded    Proposed but NOT Funded    Ground Activities



# ISS Struc and Mech Technology Demonstration Plan

## Materials, Mechanisms :

- Existing proposals in Tech Area need to be compared to Tech Area Goals for progress.
- New proposal areas need to be identified if the existing demonstrations do not meet tech area goals.

## Structures :

- Existing proposals in Tech Area need to be compared to Tech Area Goals for progress.
- New proposal areas need to be identified if the existing demonstrations do not meet tech area goals.



Mars  
(Hubble image)



Asteroid  
Ex: Asteroid 243 Ida  
and its moon  
(Galileo image)



Earth-Moon  
(KAGUYA image)

