

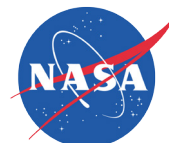
JSC SMA FLIGHT SAFETY OFFICE

Significant Incidents and Close Calls in Human Spaceflight: EVA Operations

June 28, 2018

SMA Engineering Contract
Product 6, Delivery 1
JS-2018-031
NNJ13RA01B

SAIC[®]





Significant Incidents and Close Calls in Human Spaceflight: EVA Operations

A Product of the JSC SMA Flight Safety Office

	#	%
Loss of Crew	0	0
+ Crew Injury	12	3
⏸ Early Termination	14	3
! System Issue	56	14
📋 Operational Issue	38	9

409 total spacewalks.
80 (20%) experienced significant incidents and/or close calls.
All hours represent EVA hours, not crew member hours.
All data accurate as of 6/15/2018.

! Voskhod 2	3/18/1965	• Suit ballooning impeded operations and made airlock ingress difficult.	• Workload exceeded cooling capacity.
! Gemini 4	6/3/1965	• Difficulty closing hatch after EVA.	• Workload exceeded cooling capacity.
+ Gemini 9	6/5/1966	Difficulty maneuvering.	• Multiple areas of suit damage caused a thermal burn on the crew member's back.
! Gemini 10	7/19/1966	EVA terminated early due to eye irritations from lithium hydroxide being blown into helmets when suit fans were run simultaneously.	
! Gemini 10	7/20/1966	• Umbilical blocked view of instruments and caused inadvertent shutdown of Gemini radio.	• Dislodged sharp-edged electric discharge ring.
⏸ Gemini 11, EVA 1	9/13/1966	EVA terminated early due to fatigue.	• Workload exceeded cooling capacity.
! Apollo 11, EVA 1	7/20/1969	• Difficulty passing through the LEM hatch.	
! Apollo 12, EVA 2	11/20/1969	Lunar dust abraded the EMU.	

! Apollo 15, EVA 2	7/31/1971	• Drink bag would not dispense water.	• Rover front wheel steering failed.	• Dust made EMU fittings difficult to operate.	• Hand pain from gloves pressing against fingernails.
! Apollo 15, EVA 3	8/1/1971	• Radio antenna broke – taped back in place.	• Difficulty navigating back to the LEM.		
! Apollo 16, EVA 1	4/21/1972	• Crew member slipped and fell on the PLSS after jumping.	• Lunar dust problems (jammed connectors, accelerated wear, scratches).	• Tripped over cable to heat-flow sensors.	
! Apollo 16, EVA 2	4/22/1972	• EMU radio antenna broke.			
! Apollo 16, EVA 3	4/23/1972	• Temporary LRV navigation failure.			
+ Apollo 17, EVA 1	12/11/1972	• Minor contusions from extracting stuck core sample.	• One LRV fender broke off, which resulted in the crew getting showered by dust while driving.		
! Skylab 2, EVA 2	6/7/1973	• Primary EVA heat exchanger module suffered minor clogging during the EVA, leading engineers to design a new module to serve as a backup.			
! Skylab 3, EVA 3	9/22/1973	• Water cooling system failed.			
! Skylab 4, EVA 1	11/22/1973	• Difficulty keeping umbilicals separated.			
! Skylab 4, EVA 2	12/25/1973	• Cooling water leak resulted in ice forming.			
! Skylab 4, EVA 3	12/29/1973	• Cooling water leak resulted in ice forming.			
! Skylab 4, EVA 4	2/3/1974	• Cooling water leak resulted in ice forming.			
📋 Salyut 6 PE-1, EVA 1	12/20/1977	• Safety tether not secured, but umbilical in place.			
! Salyut 6 PE-3, EVA 1	8/15/1979	• Primary pressure bladder punctured.			

+ Salyut 7 PE-1, EVA 1	7/30/1982	• Tool use resulted in wrist ring pressing on wrist and numbing hand.
! STS-41-B, EVA 1	2/7/1984	• Slidewire bracket pip-pin pulled free.
! STS-41-C, EVA 1	4/8/1984	• Hardware configuration difference prevented EVA crew member from capturing satellite. Resulted in satellite losing sun-lock and tumbling.
• Low temperature of MMU led to false low-nitrogen reading.		
! STS-41-C, EVA 2	4/11/1984	• EMU urine containment failure.
• EMU helmet fogging.		
• Small trash bag lost due to inadvertent release of MWS lock.		
+ Salyut 7 PE-3, EVA 6	8/8/1984	• One spacesuit experienced a failure of the cooling water pump.
• Physician reported the hands of the EVA crew were injured.		
📋 STS-51-L, EVA 2	9/1/1985	• EMU helmet fogging due to suit temperature adjustments.
• Difficulty in handling satellite due to lack of visual cues between EVA astronauts.		
• Accidentally reused lithium hydroxide canisters from first EVA.		
📋 Mir, PE-2, EVA 1	4/11/1987	• Incorrect switch setting resulted in temporary suit pressure decrease.

📋 Mir, PE-6, EVA 1	7/17/1990	• Procedural error damaged airlock hatch, preventing closure. Backup airlock used.
📋 Mir, PE-8, EVA 3	1/26/1991	• Inadvertent kick knocked Kurs antenna off. Not noticed until subsequent EVA.
+ STS-37, EVA 1	4/7/1991	• Palm bar punctured glove and caused minor confusion.
• Eye irritation in one crew member.		
📋 STS-37, EVA 2	4/8/1991	• Recommended against EVAs on consecutive days due to fatigue and lime constraints.
+ Mir, PE-9, EVA 6	7/27/1991	• Heat exchanger of one Orlan suit ran out of water, resulting in helmet fogging. Other cosmonaut guided crew member back.
• Crew member had bruises on hands, elbows, and shoulders.		
! Mir, PE-10, EVA 1	12/20/1992	• Heat exchanger of one Orlan suit failed to work, requiring use of umbilical for cooling. Umbilical limited translation range.
• Crew member conducted portions of EVA alone.		
! Mir, PE-13, EVA 1	4/19/1993	• Orlan suit ventilation problems.
📋 STS-57, EVA 1	6/25/1993	• Cold to point of experiencing hand pain.
• Almost lost untethered piece of IUS tilt table equipment.		
⏸ Mir, PE-14, EVA 3	9/28/1993	EVA terminated early due to Orlan suit cooling system failure.
! Mir, PE-14, EVA 4	10/22/1993	EVA terminated early due to Orlan suit oxygen flow system problem.
! STS-61, EVA 2	12/5/1993	• One EV experienced radio problems.
+ STS-63, EVA 2	2/9/1995	• EVA terminated early when EV became "unacceptably cold."
• One EV experienced eye irritation, likely from anti-fog agent.		
⏸ STS-80, EVA 1	11/29/1996	EVA terminated early. Loose screw jammed airlock hatch latch mechanism, preventing operation.
! STS-86, EVA 1	10/1/1997	• SAFER pyro failed to fire. Resulting lack of self-rescue led to redesign.
! STS-96/2A.1	5/27-6/6/1999	• SAFER NSI (pyro) inadvertently fired on orbit, resulting in pyrotechnic isolation valve opening and loss of gaseous nitrogen. Condition identified post-landing.

+ STS-97/4A, EVA 1	12/3/2000	• Crew member experienced eye irritation, likely from anti-fog agent used in helmet.
📋 STS-98/5A, EVA 1	2/10/2001	• EV2 was sprayed with ammonia and required decontamination procedure (aka "bakeout").
+ STS-100/6A, EVA 1	4/22/2001	• EV1 experienced eye irritation in both eyes. Attributed to leaking in-suit drink bag and anti-fog agent used in helmet.
+ STS-100/6A, EVA 2	4/24/2001	• EV1 experienced eye irritation in both eyes. Attributed to leaking in-suit drink bag and anti-fog agent used in helmet.
! ISS Exp-9 US EVA Ops	5/19/2004	• Temporary loss of ISS U.S. EVA capability due to EMU cooling loop contamination.
⏸ RS EVA 9A	6/24/2004	EVA terminated early due to misconfigured valve depleting Orlan suit oxygen supply at start of EVA.
📋 RS EVA 10	8/3/2004	• CMGs saturated during EVA. ISS went into free drift. No IVA crew.
📋 STS-121/ULF1.1, EVA 2	7/10/2006	• EV1's SAFER left tower latch was bumped into the unlatched position, resulting in the left tower disengaging from the EMU. EVA was suspended until latch could be re-engaged by EV2.
📋 STS-116/12A.1, EVA 1	12/12/2006	• EV1's SAFER HCM inadvertently deployed during airlock egress. EV2 re-stowed HCM on second attempt. SAFER NSI (pyro) accidentally fired.
⏸ STS-118/13A.1, EVA 3	8/15/2007	EVA terminated early due to cut glove.
! STS-120/10A, EVA 3	10/30/2007	• One EMU unusable after EVA due to degraded sublimator.
📋 RS EVA 20A	7/10/2008	• Jettisoned Soyuz thruster cover collided with U.S. radiator.
⏸ STS-126/ULF2, EVA 2	11/20/2008	• One EV experienced high carbon dioxide levels. EVA terminated early.
⏸ STS-126/ULF2, EVA 4	11/24/2008	• One EV experienced high carbon dioxide levels. EVA terminated early.
📋 RS EVA 21A	3/10/2009	• EVs working close to rotating port Service Module solar array. Solar arrays should have been parked for EVA.
⏸ STS-125/HST, EVA 4	5/17/2009	EVA terminated early.
⏸ STS-127/2JA, EVA 3	7/22/2009	• One EV experienced high carbon dioxide levels. EVA terminated early.
📋 STS-128/17A, EVA 3	9/5/2009	• EMU camera and light detached from helmet, but held captive by electrical cable.

! STS-130/20A, EVA 1	2/11/2010	• EV2 observed water droplets in helmet and sensed water at feet.
! STS-130/20A, EVA 2	2/14/2010	• EV2 exposed to ammonia from leaking quick-disconnect.
! STS-130/20A, EVA 3	2/17/2010	• EV1 observed water droplets in helmet.
📋 U.S. EVA 15	8/7/2010	• EV1 exposed to ammonia from leaking quick-disconnect and experienced difficulty actuating quick-disconnect.
! U.S. EVA 16	8/11/2010	• EV1 exposed to ammonia from leaking quick-disconnect and experienced difficulty actuating quick-disconnect.
! STS-134/ULF6, EVA 1	5/20/2011	• Carbon dioxide sensor failure resulted in reduced EVA timeline.
+ STS-134/ULF6, EVA 3	5/25/2011	• One EV experienced eye irritation, likely from anti-fog agent.
! U.S. EVA 18	8/30/2012	• EV2 experienced elevated EMU water cooling loop temperatures.
! U.S. EVA 22	7/9/2013	• Crew member observed the presence of water in the EMU helmet.
⏸ U.S. EVA 23	7/16/2013	• 1 to 1.5 liters of water entered the EMU ventilation loop and collected in the EMU helmet. EVA terminated early.
📋 U.S. EVA 24	12/21/2013	• After returning to the airlock, an EMU feedwater switch procedural error resulted in water flooding the sublimator rendering EMU no-go for EVA.
! U.S. EVA 25	12/24/2013	• Crew members experienced difficulty disconnecting ammonia fluid lines and reported seeing ammonia flakes escaping a valve.
📋 U.S. EVA 32	10/28/2015	• EMU feedwater switch inadvertently switched on prior to the airlock being at vacuum.
⏸ U.S. EVA 35	1/15/2016	• EV1 observed water in helmet. EVA terminated early.
📋 U.S. EVA 38	1/6/2017	• Crew used glove in hammer-like manner. Glove removed from flight use.
! U.S. EVA 41	3/30/2017	• Helmet lights detached from helmet, but were held captive by the electrical cable.
! U.S. EVA 42	5/12/2017	• One SCU failed during pre-breathe. Crew exposed to high temperatures during depress.
! U.S. EVA 46	10/20/2017	• Inadvertent SAFER pyro activation during EVA, resulting in loss of gaseous nitrogen. Discovered late in EVA.

1960s: 25 Hours = 24 U.S. + 1 Russia
18 EVAs = 16 U.S. + 2 Russia

1970s: 121 Hours = 116 U.S. + 5 Russia
32 EVAs = 29 U.S. + 3 Russia

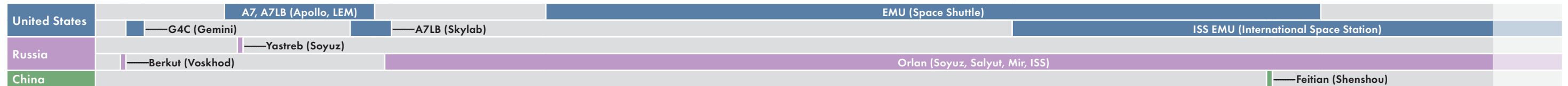
1980s: 146 Hours = 69 U.S. + 77 Russia
33 EVAs = 13 U.S. + 20 Russia

1990s: 557 Hours = 231 U.S. + 326 Russia
106 EVAs = 35 U.S. + 71 Russia

2000s: 900 Hours* = 755 U.S. + 144 Russia
144 EVAs* = 113 U.S. + 30 Russia

2010s: 470 Hours = 334 U.S. + 136 Russia
75 EVAs = 53 U.S. + 22 Russia

* Total hours and EVAs include 1 Chinese EVA with a duration of 1 hour.

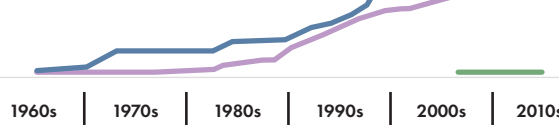


45 EVAs with Inadvertent Releases

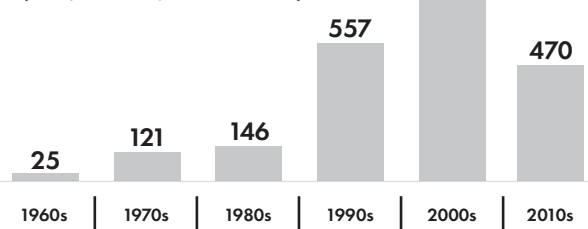
Mission ID	EVA	# lost	Year	Mission ID	EVA	# lost	Year	Mission ID	EVA	# lost	Year
Gemini 4	1	1	1965	STS-100/6A	2	1	2001	ISS-16	US 11	1	2007
Gemini 10	1	1	1966	STS-104/7A	3	1	2001	ISS-16	US 13	4	2007
Salyut 7	1	1	1983	STS-102/5A.1	1	2	2002	ISS-16	US 14	1	2008
STS-41-B	2	1	1984	ISS-4	RS 6	1	2002	STS-124/1J	2	1	2008
STS-41-C	2	1	1984	ISS-11	US 13	1	2005	STS-126/ULF2	1	1	2008
STS-41-G	1	1	1984	ISS-12	US 4	1	2005	ISS-24	RS 25	4	2010
STS-51-A	2	2	1984	ISS-13	RS 16	1	2006	ISS-25	RS 26	1	2010
STS-51-L	1	1	1985	STS-121/ULF1.1	3	1	2006	ISS-26	RS 27	1	2011
Mir	PE-13	1	1993	STS-115/12A	1	1	2006	STS-133/ULF5	1	1	2011
STS-88/2A	1	4	1998	STS-115/12A	2	1	2006	STS-134/ULF6	2	4	2011
STS-88/2A.1	2	3	1998	STS-116/12A.1	1	1	2006	ISS-28	RS 29	1	2011
STS-96/2A.1	1	1	1999	STS-116/12A.1	3	1	2006	ISS-35	RS 32	1	2013
STS-103/HST	3	1	1999	ISS-14	RS 17A	3	2007	ISS-39	US 26	2	2014
STS-101/2A.2a	1	1	2000	ISS-15	RS 18	1	2007	ISS-50	US 41	1	2017
STS-92/3A	3	1	2000	STS-120/10A	4	2	2007	ISS-53	US 44	1	2017

Cumulative Hours

U.S. - 1528
Russian - 689
Chinese - 1



Total Hours by decade. (U.S., Russian, and Chinese)



The JSC SMA Flight Safety Office created this graphic to highlight the risks of space exploration and to provide engineers with a summary of past experience. The chart depicts incidents during EVAs in orbit and on the lunar surface, which caused or could have caused injury, death, or the loss of the mission. Our goal is to encourage everyone to learn from the past to make present and future missions safer.

Event Criteria

Incidents on the chart meet one or more of the following criteria:

1. Resulted in loss of life or could have resulted in loss of life under different conditions or circumstances (e.g., close calls, accidental crew detachment, water in helmet, EVA operations in thruster keep-out zone, failure to constrain/inhibit Ku Band operations...).
2. Resulted in injury or temporary incapacitation of a crew member, or otherwise compromised the crew member's ability to perform critical tasks, such as self-rescue (e.g., frost bite, anti-fog agent in eyes).
3. Resulted in the potential for critical or catastrophic damage to spacecraft (e.g., damaged hatch seal, damage to wiring harness, damage to suit, jettisoned equipment collision, or inadvertent release).
4. EVA aborted or terminated early to protect the crew.
5. Unique significance based on expert opinion (e.g., precursor events and minor events related to subsequent, more significant events, such as water-in-suit events, planetary protection, etc.).

Acronyms

CMG	Control Moment Gyroscope	NASA	National Aeronautics and Space Administration
DTO	Developmental Test Objective	NSI	NASA Standard Initiator
EMU	Extravehicular Mobility Unit	PE	Principal Expedition
EVA	Extravehicular Activity	PLSS	Primary Life Support System
EV	EVA Crew Member	RCC	Reinforced Carbon-Carbon
FSO	Flight Safety Office	RS	Russia/Russian
HCM	Hand Control Module	SAFER	Simplified Aid for EVA Rescue
HST	Hubble Space Telescope	SAIC	Science Applications International Corporation
ISS	International Space Station	SCU	Service and Cooling Umbilical
IUS	Inertial Upper Stage	SMA	Safety and Mission Assurance
IVA	Intravehicular Activity	STS	Space Transportation System
JSC	Johnson Space Center	U.S.	United States
LEM	Lunar Excursion Module	ULF	Utilization Logistics Flight
LRV	Lunar Roving Vehicle		
MMU	Manned Maneuvering Unit		
MWS	Mini-Workstation		

This quick-reference sheet is a product of the JSC SMA Flight Safety Office (FSO). Our reports assemble and clarify the best-available data from multiple sources to help SMA decision makers develop a fully informed and integrated perspective of key factors involved in the risk-based decision process. For further information, please contact:

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