JSC SMA FLIGHT SAFETY OFFICE

Significant Incidents and Close Calls in Human Spaceflight: EVA Operations

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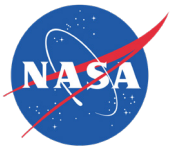


Significant Incidents and Close Calls in Human Spaceflight: EVA Operations

A Product of the JSC SMA Flight Safety Office

United States | Russia | China

	#	%
Loss of Crew	0	0
Crew Injury	15	3
Early Termination	14	3
System Issue	59	13
Operational Issue	44	9

481 total spacewalks.
97 (20%) experienced significant incidents and/or close calls.

All hours represent EVA hours, not crew member hours.

All data accurate as of 8/30/2024.

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.
- Workload exceeded cooling capacity.

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-51D 4/16/1985
- Crew member tumbled out of payload bay.

STS-51-I, 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 contusion.
- Eye irritation in one crew member.

STS-37, EVA 2 4/8/1991
- Recommended against EVAs on consecutive days due to fatigue and time 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-88, EVA 1 12/7/1998
- EV crew member pushed off from the ISS in an attempt to retrieve a lost object.

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-98/5A, EVA 2 2/12/2001
- One of the crew members reported experiencing severe foot problems during the EVA.

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 U.S. 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.

RS EVA 13 3/28/2005
- 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-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-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
- Excess water accumulation in EVA helmet resulted in near-drowning. EVA terminated.

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.

U.S. EVA 53 3/29/2019
- APFR Ingress Aid came off in crew member's hand during APFR relocation.

U.S. EVA 62 1/15/2020
- EMU camera assembly and helmet lights detached from helmet, but were held captive by the electrical cable.

U.S. EVA 62 1/15/2020
- One EV experienced eye irritation.

U.S. EVA 63 1/20/2020
- One EV experienced eye irritation.

U.S. EVA 64 1/25/2020
- Strap stuck in IV hatch during depress.

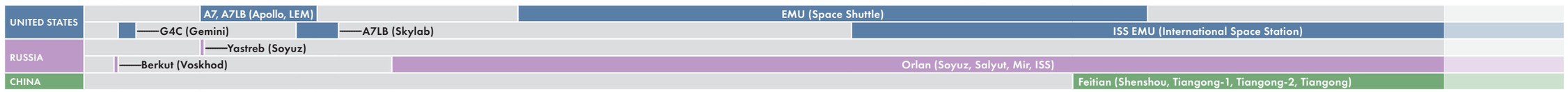
RS EVA ESA 7/21/2022
- Nanosat deployed during EVA struck the Service Module's port solar array.

RS EVA 54 8/17/2022
- Orlan-MKS low battery voltage resulted in early termination of EVA.

U.S. EVA 90 6/24/2024
- The Service and Cooling Umbilical leaked water after it was disconnected, resulting in water and ice on the EMU and snow in the airlock.

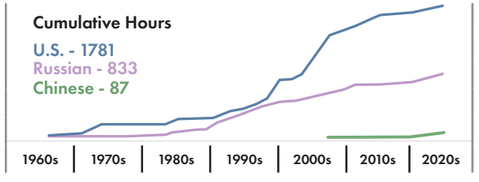
1960s	25 Hours = 24 U.S. + 1 Russia	18 EVAs = 16 U.S. + 2 Russia
1970s	121 Hours = 116 U.S. + 5 Russia	32 EVAs = 29 U.S. + 3 Russia
1980s	146 Hours = 69 U.S. + 77 Russia	33 EVAs = 13 U.S. + 20 Russia
1990s	557 Hours = 231 U.S. + 326 Russia	106 EVAs = 35 U.S. + 71 Russia
2000s	900 Hours* = 755 U.S. + 144 Russia	144 EVAs* = 113 U.S. + 30 Russia
2010s	558 Hours = 400 U.S. + 158 Russia	88 EVAs = 63 U.S. + 25 Russia
2020s	394 Hours = 186 U.S. + 122 Russia + 86 China	60 EVAs = 29 U.S. + 18 Russia + 13 China

* Includes 1 Chinese EVA with a duration of 1 hour.



53 EVAs with Inadvertent Releases

Mission ID	Mission ID	Mission ID	Mission ID	Mission ID
Gemini 4	STS-96/2A.1	STS-121/ULF1.1	STS-124/1J	ISS-53
Gemini 10	STS-103/HST	STS-115/12A	STS-126/ULF2	ISS-56
Salyut 7	STS-101/2A.2a	STS-115/12A	ISS-24	ISS-59
STS-41-B	STS-92/3A	STS-116/12A.1	ISS-25	ISS-63
STS-41-C	STS-100/6A	STS-116/12A.1	ISS-26	ISS-64
STS-41-G	STS-104/7A	ISS-14	STS-133/ULF5	ISS-67
STS-51-A	STS-102/5A.1	ISS-15	STS-134/ULF6	ISS-67
STS-51-I	ISS-4	STS-120/10A	ISS-28	ISS-68
Mir	ISS-11	ISS-16	ISS-35	ISS-70
STS-88/2A	ISS-12	ISS-16	ISS-39	
STS-88/2A	ISS-13	ISS-16	ISS-50	



Cut Gloves

STS-118/13A.1, EVA 3 8/15/2007
- EVA terminated early due to cut glove.

STS-125/HST, EVA 4 5/17/2009
- Tear in palm of EMU glove noticed when EVA was near completion. EVA terminated early.

OTHER SIGNIFICANT CUT GLOVE EVENTS HAVE OCCURRED ON:
STS-116, STS-120, STS-129, U.S. EVA 31, U.S. EVA 62

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

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

This 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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