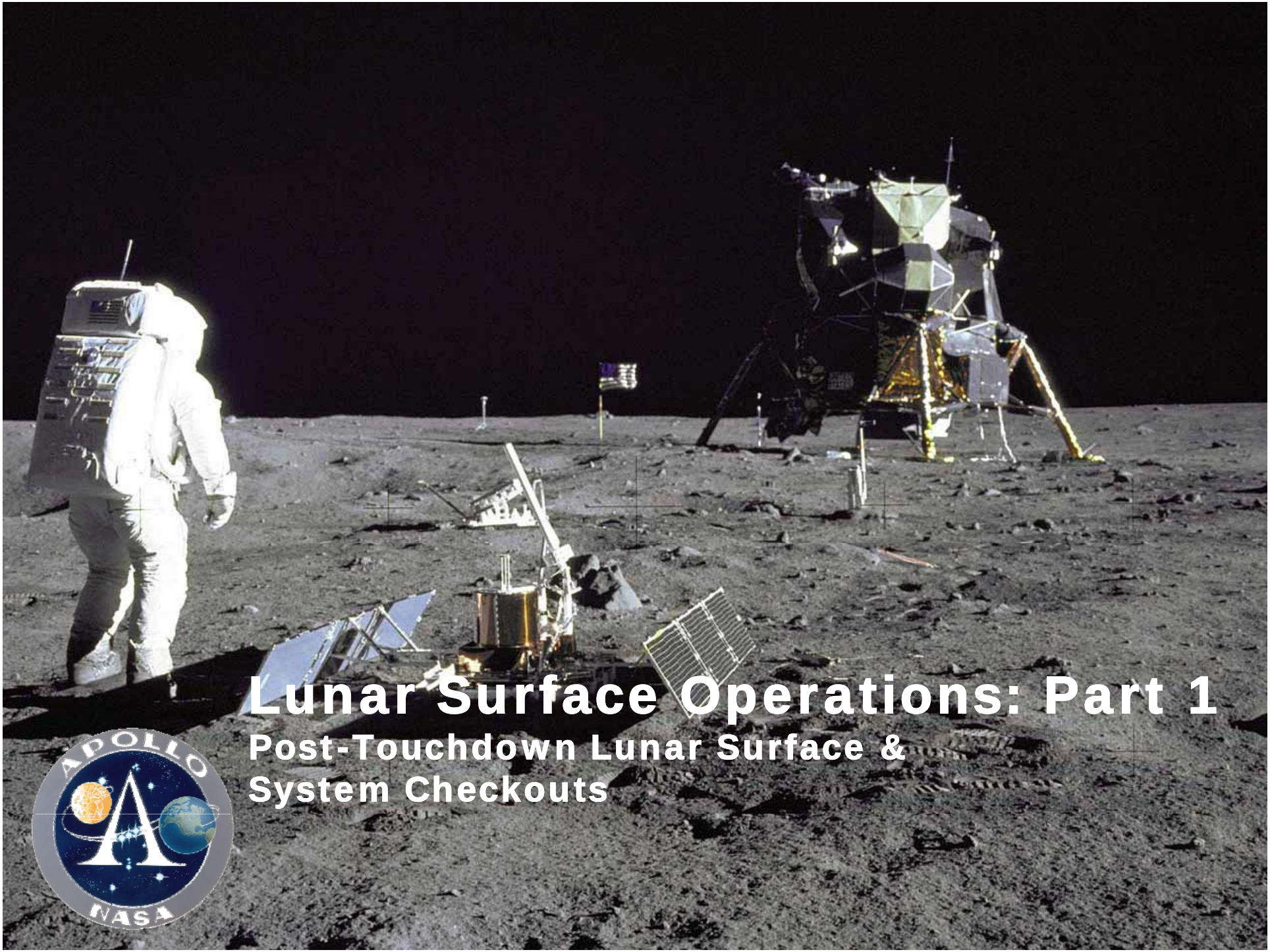
Lunar Surface Operations: Part 1
Post-Touchdown Lunar Surface &
System Checkouts
APOLLO
NASA

Objectives

Describe postlanding activities, Stay/No Stay decisions

Describe Systems Checkout tasks, alignments, landing site position determination

Part 1	Part 2	Part 3
Post-Touchdown Lunar Surface & Systems Checkout	Surface Duration	Pre-Launch Lunar Surface & CSM Plane Change

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answers to the following questions:

1. Is the LM stable on the lunar surface?

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answer to the following questions:

1. Is the LM stable on the lunar surface?

   Tilt Angle < 30°

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answer to the following questions:

1. Is the LM stable on the lunar surface?

   Tilt Angle < 30°

2. Are there any time critical systems failures or trends indicating impending loss of capability to ascent and achieve a safe lunar orbit?

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answer to the following questions:

1. Is the LM stable on the lunar surface?

   Tilt Angle < 30°

2. Are there any time critical systems failures or trends indicating impending loss of capability to ascent and achieve a safe lunar orbit?

   Guidance and Propulsion Systems - Go

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answer to the following questions:

1. Is the LM stable on the lunar surface?

   Tilt Angle < 30°

2. Are there any time critical systems failures or trends indicating impending loss of capability to ascent and achieve a safe lunar orbit?

   Guidance and Propulsion Systems - Go

3. Is there loss of capability in critical LM systems?

Post-Touchdown Phase:
First Stay / No Stay Decision

Decision was based on the answer to the following questions:

1. Is the LM stable on the lunar surface?

   Tilt Angle < 30°

2. Are there any time critical systems failures or trends indicating impending loss of capability to ascent and achieve a safe lunar orbit?

   Guidance and Propulsion Systems - Go

3. Is there loss of capability in critical LM systems?

   Electrical, Environmental, Communications Systems - Go

Post-Touchdown Phase:
First Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown = 0:00	Depress - Engine Stop pb
	Monitor Flight Director Attitude Indicator (FDAI) for tilt over abort
	Push – ‘PRO’ on Display/Keyboard (DSKY) to prevent Reaction Control System (RCS) firings
	LM Primary Guidance, Navigation, and Control System (PGNCS) Mode Control switch - AUTO
	Descent Engine Command Override - OFF
	Engine Arm - OFF
	Data Entry & Display Assembly (DEDA) entry for Abort Guidance System (AGS) lunar surface confirmation
	FIRST STAY/NO STAY DECISION MADE
0:03.5	T1 (first preferred lift-off time)

Post-Touchdown Phase:
First Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown = 0:00	Depress - Engine Stop pb
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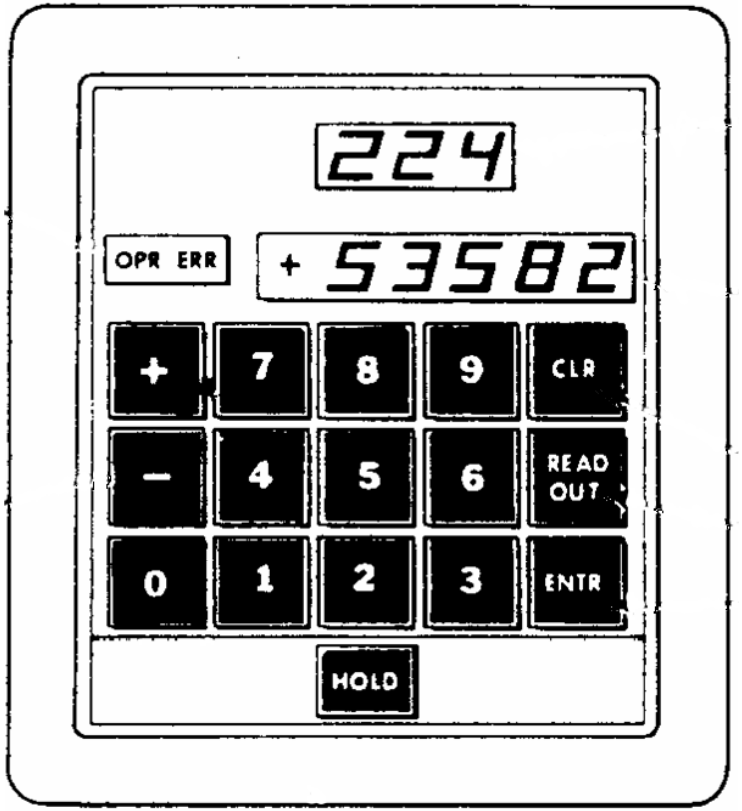

Post-Touchdown Phase:
First Stay / No Stay Decision

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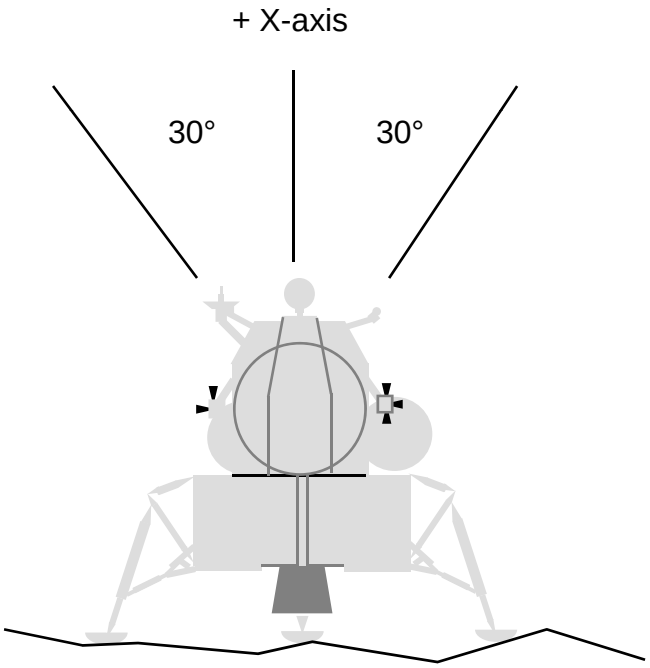
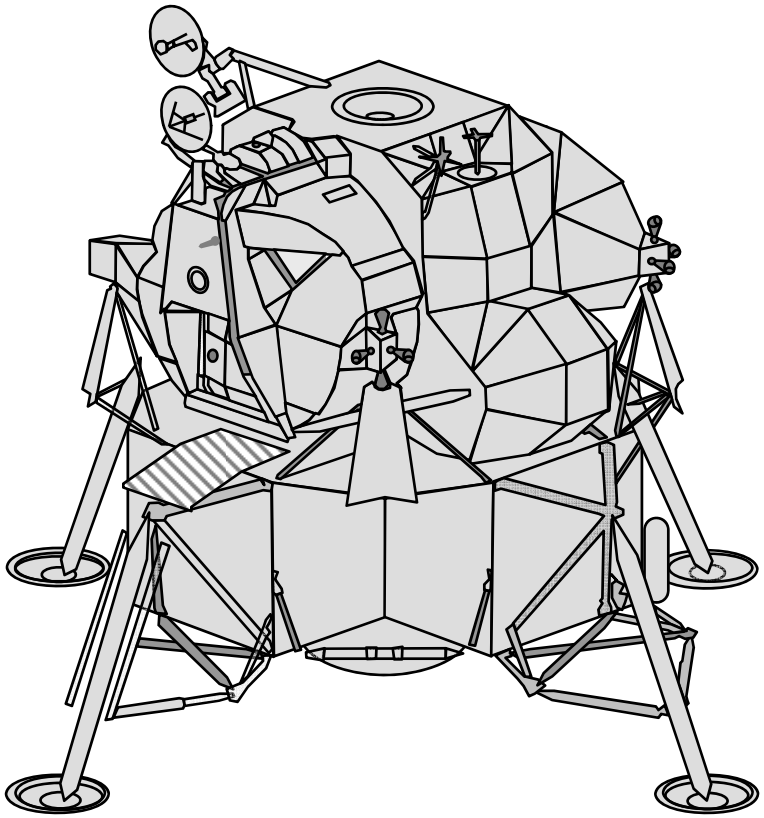


Post-Touchdown Phase:
First Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown = 0:00	Depress - Engine Stop pb
	Monitor Flight Director Attitude Indicator (FDAI) for tilt over abort
	Push – 'PRO' on Display/Keyboard (DSKY) to prevent Reaction Control System (RCS) firings
Guidance – STAY?	LM Primary Guidance, Navigation, and Control System (PGNCS) Mode Control switch - AUTO
Electrical Systems – STAY?	Descent Engine Command Override - OFF
Environmental Systems – STAY?	Engine Arm - OFF
Comm Systems – STAY?	Data Entry & Display Assembly (DEDA) entry for Abort Guidance System (AGS) lunar surface confirmation
Prop Systems – STAY?	FIRST STAY/NO STAY DECISION MADE
+ 0:03.5	T1 (first preferred lift-off time)

Post-Touchdown Phase:
Second Stay / No Stay Decision

Decision based on more thorough assessment by crew and MCC of critical vehicle systems, but vehicle maintained launch ready.



Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:3.5	Landing Radar (LR) - OFF
	Load Abort Guidance System (AGS) state vector
	Enter AGS Lunar Align
	Select P68 – Landing Confirmation Program
	Select P12 (Ascent Program), input lift-off time from pre Powered Descent Initiation (PDI) pad
0:07	Exit AGS Lunar Align and enable guidance steering
	SECOND STAY/NO STAY DECISION MADE (for at least one Command Service Module (CSM) revolution)
0:09	T2 (Second preferred lift-off time)

Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:3.5	Landing Radar (LR) - OFF
	Load Abort Guidance System (AGS) state vector
	Enter AGS Lunar Align
	Select P68 – Landing Confirmation Program
	Select P12 (Ascent Program), input lift-off time from pre Powered Descent Initiation (PDI) pad
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	SECOND STAY/NO STAY DECISION MADE (for at least one Command Service Module (CSM) revolution)
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Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:3.5	Landing Radar (LR) - OFF
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Post-Touchdown Phase:
Second Stay / No Stay Decision

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Touchdown + 0:3.5	Landing Radar (LR) - OFF
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Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:3.5	Landing Radar (LR) - OFF
	Load Abort Guidance System (AGS) state vector
	Enter AGS Lunar Align
	Select P68 – Landing Confirmation Program
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	SECOND STAY/NO STAY DECISION MADE (for at least one Command Service Module (CSM) revolution)
+ 0:09	T2 (Second preferred lift-off time)

Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:09	Mode Control Switch (AGS) – OFF
	Mode Control Switch Primary Guidance, Navigation, & Control System (PGNCS) – ATTITUDE HOLD

Post-Touchdown Phase:
Second Stay / No Stay Decision

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:09	Mode Control Switch (AGS) – OFF Mode Control Switch Primary Guidance, Navigation, & Control System (PGNCS) – ATTITUDE HOLD

Systems Checkouts

Alignments, Drift Checks, and State Vector Updates

Essentially, these tasks were performed to provide the most accurate LM position on the moon for guidance and insure that all guidance systems had the most accurate state vector data, and IMU alignment, both of which were essential for ascent.

The various alignment techniques were used to obtain most accurate IMU alignment.

IMU were highly susceptible to drift, so alignments were done repeatedly.

Alignment Options

- Alignment Techniques (AT)

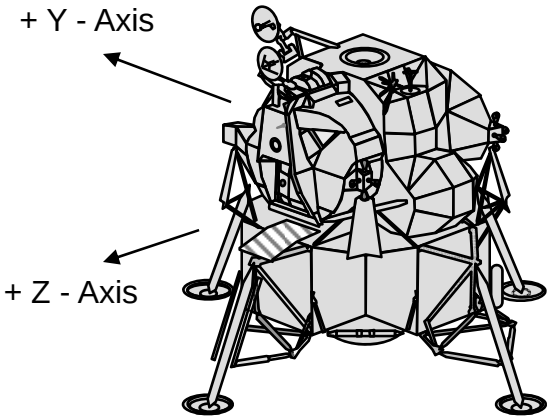
AT-0 : LM Y & Z body axis

AT-1: Z body axis & measured gravity vector

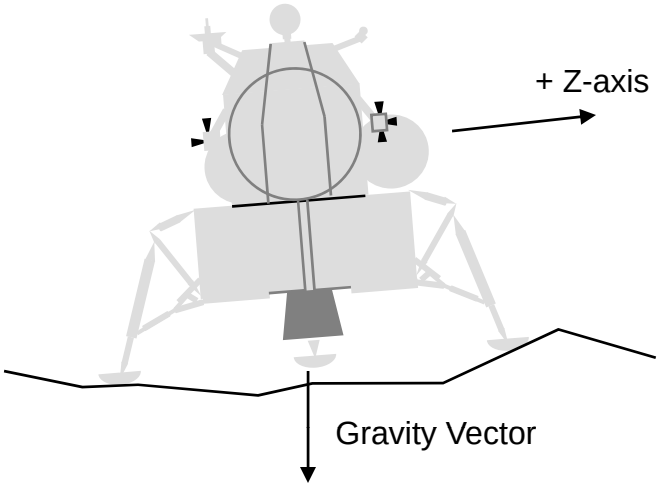
AT-2: Two star vectors

AT-3: Star Vector & measured gravity vector

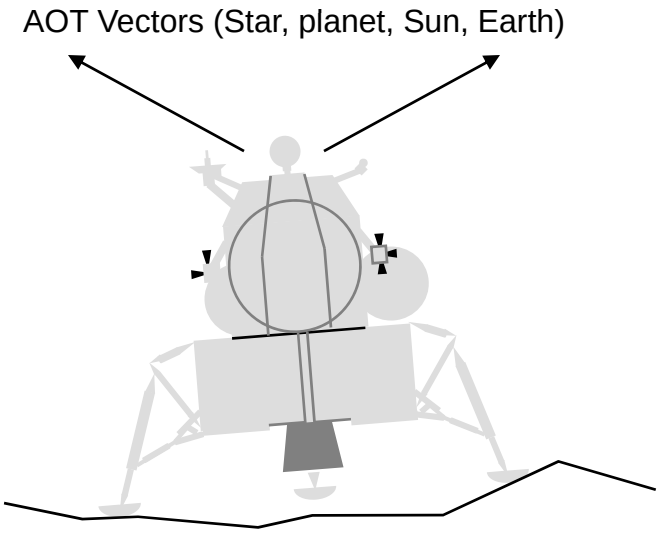
Alignment Options



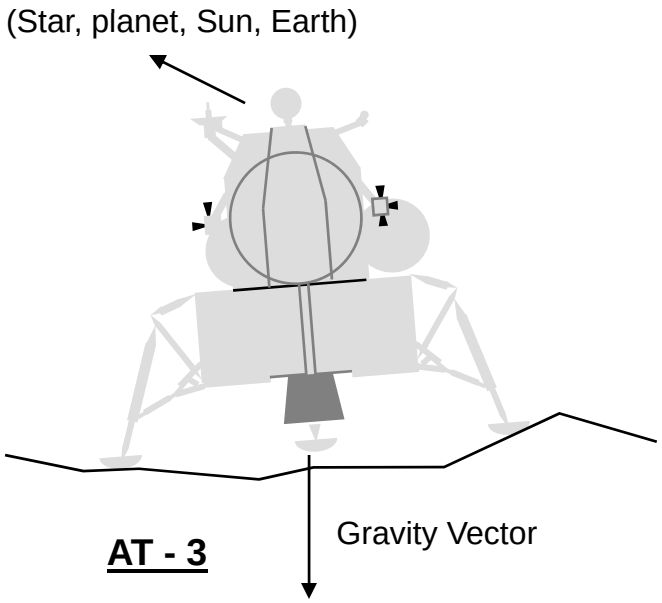
AT - 0



AT - 1



AT - 2



AT - 3

Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:15	Perform Abort Guidance System (AGS) Lunar Surface Gyro calibration
	Set AGS insertion altitude rate to 32 feet per second
+ 0:20	Select P57 (LM Guidance Computer Lunar Surface Alignment Program) Alignment Technique 1 (AT-1) gravity measurement with no gyro torquing
	Crew survey estimate of LM position vector on lunar surface (RLS) voiced to ground
+ 0:30	Select P57, AT-2, align Inertial Measurement Unit (IMU) to pre Powered Descent Initiation (PDI) REFSMMAT using two celestial bodies. Compute updated RLS. Repeat the above.
+ 1:00	Align AGS to Primary Guidance, Navigation, & Control System (PGNCS)
	Store the updated AGS azimuth
	Readout AGS azimuth to the ground

Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 0:15	Perform Abort Guidance System (AGS) Lunar Surface Gyro calibration
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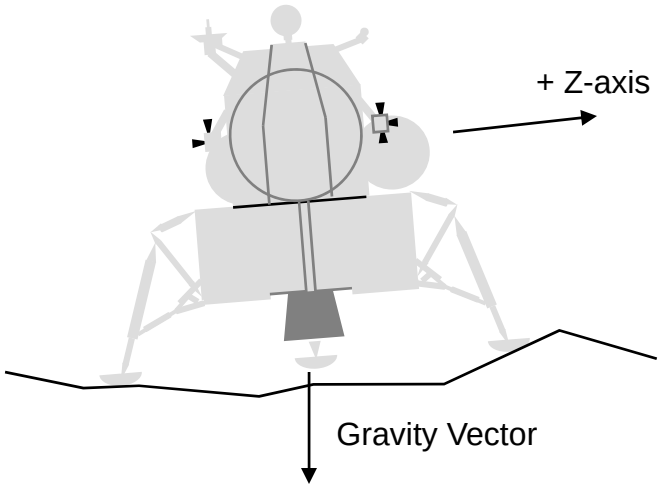

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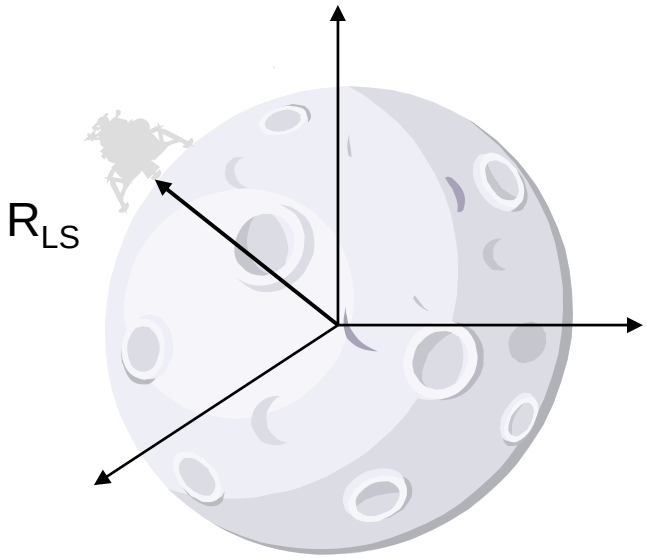
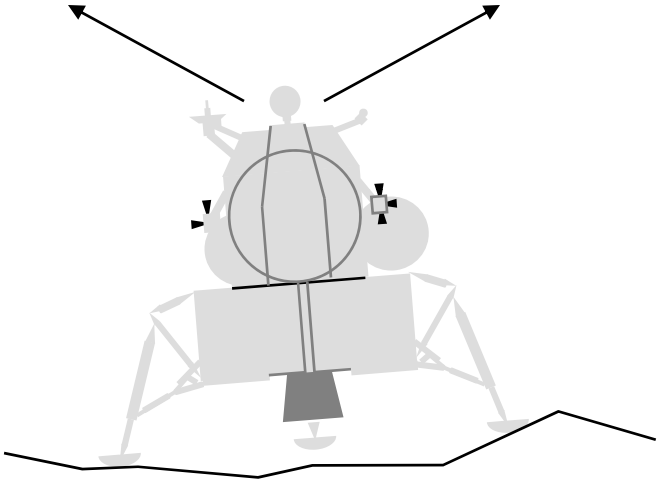


Systems Checkout

Time (hr:min)

AOT Vectors (Star, planet, Sun, Earth)



+ 0:30

+ 1:00

Lunar Module (LM) Activity

Perform Abort Guidance System (AGS) Lunar Surface Gyro calibration

Set AGS insertion altitude rate to 32 feet per second

Select P57 (LM Guidance Computer Lunar Surface Alignment Program) Alignment Technique 1 (AT-1) gravity measurement with no gyro torquing

Crew survey estimate of LM position vector on lunar surface (RLS) voiced to ground

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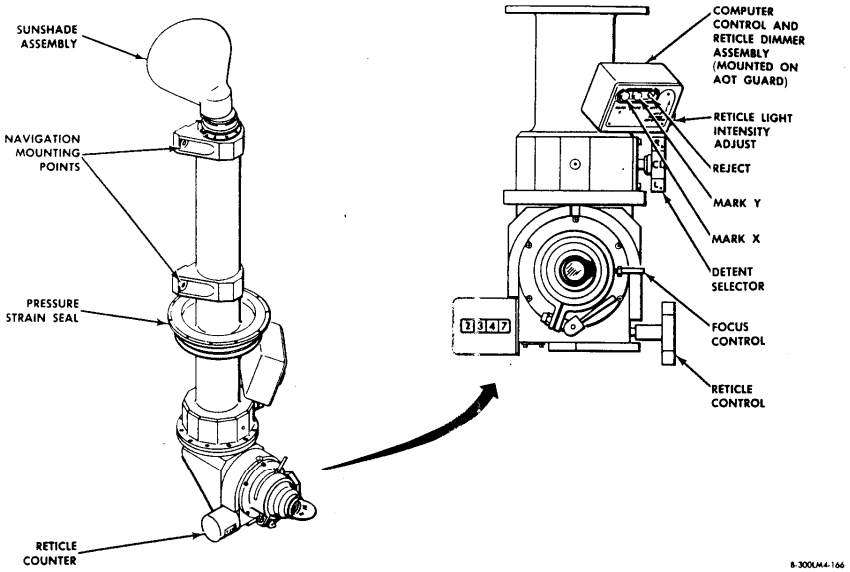
Systems Checkout

Time (hr:min)



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Align AGS to Primary Guidance, Navigation, & Control System (PGNCS)

Store the updated AGS azimuth

Readout AGS azimuth to the ground

Systems Checkout

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	Store the updated AGS azimuth
	Readout AGS azimuth to the ground

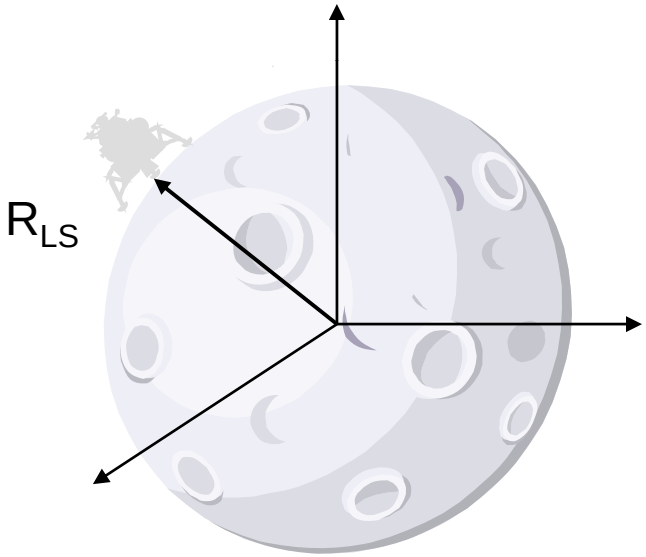
Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 1:00	Enter Abort Guidance System (AGS) insertion targeting
	Receive uplinked LM position vector on the lunar surface (RLS) (if different from onboard) and Command Service Module (CSM) state vector
1:20	Confirm Stay/No Stay for lunar stay. Receive recommendation of best guidance system for launch
1:45	Select P22 (Landmark Tracking Program) – Rendezvous Radar (RR) tracking of CSM
2:00	Power down RR, AGS, LM Guidance Computer (LGC), and Inertial Measurement Unit (IMU) to STANDBY

Systems Checkout

Time (hr:min)

Touchdown + 1:00



Lunar Module (LM) Activity

Enter Abort Guidance System (AGS) insertion targeting

Receive uplinked LM position vector on the lunar surface (RLS) (if different from onboard) and Command Service Module (CSM) state vector

Confirm Stay/No Stay for lunar stay. Receive recommendation of best guidance system for launch

Select P22 (Landmark Tracking Program) – Rendezvous Radar (RR) tracking of CSM

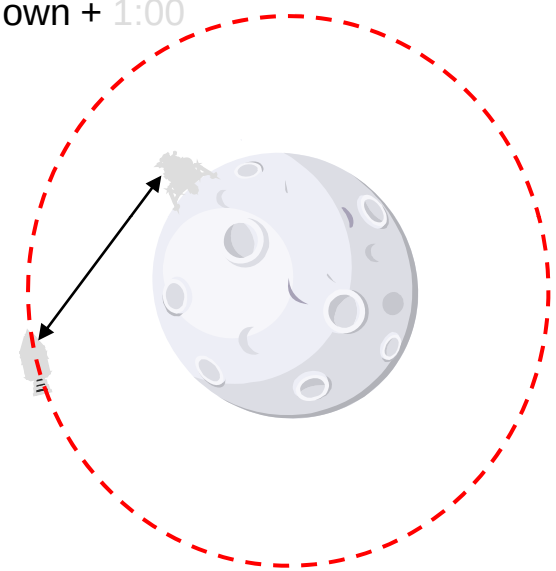
Power down RR, AGS, LM Guidance Computer (LGC), and Inertial Measurement Unit (IMU) to STANDBY

Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 1:00	Enter Abort Guidance System (AGS) insertion targeting
	Receive uplinked LM position vector on the lunar surface (RLS) (if different from onboard) and Command Service Module (CSM) state vector
+ 1:20	Confirm Stay/No Stay for lunar stay. Receive recommendation of best guidance system for launch
+ 1:45	Select P22 (Landmark Tracking Program) – Rendezvous Radar (RR) tracking of CSM
+ 2:00	Power down RR, AGS, LM Guidance Computer (LGC), and Inertial Measurement Unit (IMU) to STANDBY

Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 1:00	Enter Abort Guidance System (AGS) insertion targeting
	Receive uplinked LM position vector on the lunar surface (RLS) (if different from onboard) and Command Service Module (CSM) state vector
	Confirm Stay/No Stay for lunar stay. Receive recommendation of best guidance system for launch
+ 1:45	Select P22 (Landmark Tracking Program) – Rendezvous Radar (RR) tracking of CSM
	Power down RR, AGS, LM Guidance Computer (LGC), and Inertial Measurement Unit (IMU) to STANDBY



Systems Checkout

Time (hr:min)	Lunar Module (LM) Activity
Touchdown + 1:00	Enter Abort Guidance System (AGS) insertion targeting
	Receive uplinked LM position vector on the lunar surface (RLS) (if different from onboard) and Command Service Module (CSM) state vector
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+ 2:00	Power down RR, AGS, LM Guidance Computer (LGC), and Inertial Measurement Unit (IMU) to STANDBY

Systems Checkout

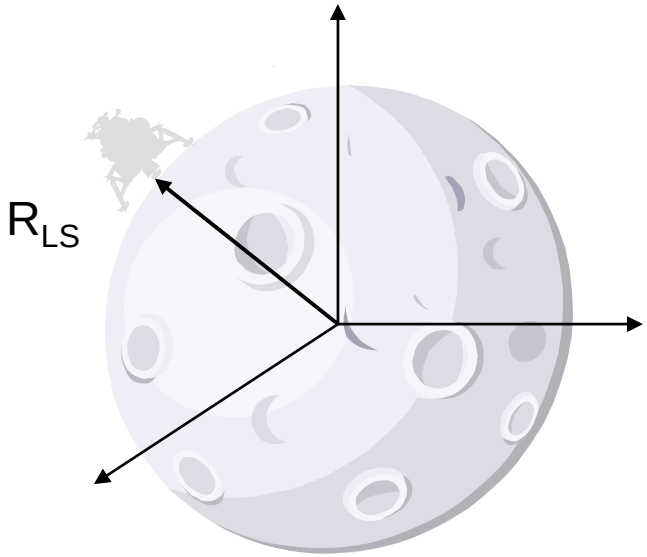
Time (hr:min)	Command Service Module (CSM) Activity
Touchdown + 0:15	Select P52 (Inertial Measurement Unit (IMU) Realignment program) to pre Powered Descent Initiation (PDI) REFSMMAT
1:20	Confirm Stay/No Stay for nominal lunar stay
	Receive Lunar Module (LM) position vector on the lunar surface (RLS) and CSM state vector
1:45	Select P22 (Landmark Tracking Program) – Sextant (SXT) tracking of landmark

Systems Checkout

Time (hr:min)	Command Service Module (CSM) Activity
Touchdown + 0:15	Select P52 (Inertial Measurement Unit (IMU) Realignment program) to pre Powered Descent Initiation (PDI) REFSMMAT
+ 1:20	Confirm Stay/No Stay for nominal lunar stay
	Receive Lunar Module (LM) position vector on the lunar surface (RLS) and CSM state vector
1:45	Select P22 (Landmark Tracking Program) – Sextant (SXT) tracking of landmark

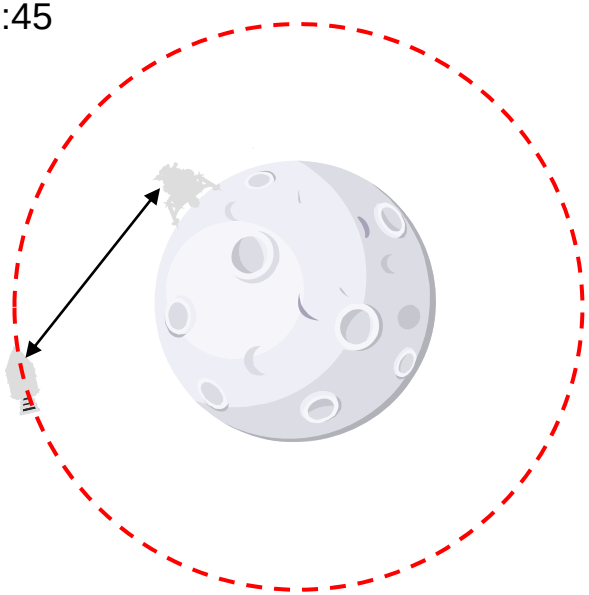
Systems Checkout

Time (hr:min)	Command Service Module (CSM) Activity
Touchdown + 0:15	Select P52 (Inertial Measurement Unit (IMU) Realignment program) to pre Powered Descent Initiation (PDI) REFSMMAT
+ 1:20	Confirm Stay/No Stay for nominal lunar stay
	Receive Lunar Module (LM) position vector on the lunar surface (RLS) and CSM state vector
	Select P22 (Landmark Tracking Program) – Sextant (SXT) tracking of landmark



Systems Checkout

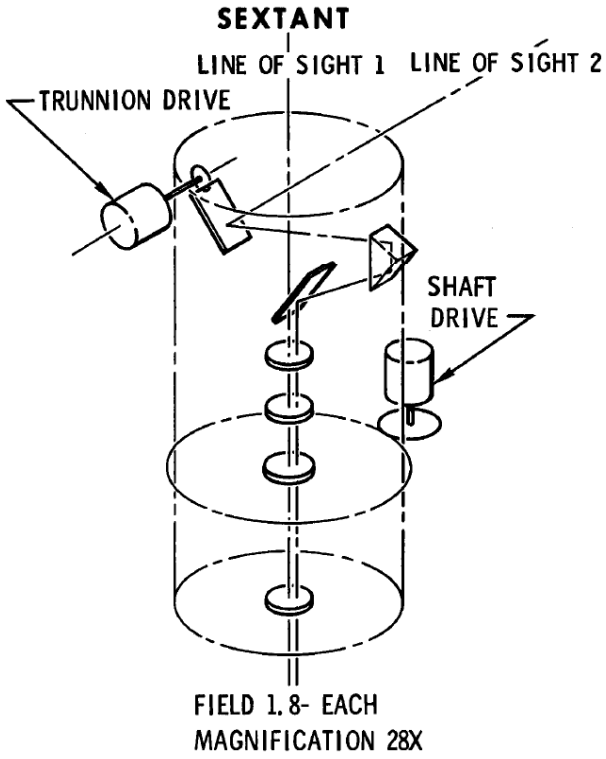
Time (hr:min)	Command Service Module (CSM) Activity
Touchdown + 0:15	Select P52 (Inertial Measurement Unit (IMU) Realignment program) to pre Powered Descent Initiation (PDI) REFSMMAT
+ 1:20	Confirm Stay/No Stay for nominal lunar stay
	Receive Lunar Module (LM) position vector on the lunar surface (RLS) and CSM state vector
+ 1:45	Select P22 (Landmark Tracking Program) – Sextant (SXT) tracking of landmark



Systems Checkout

Time (hr:min)

Touchdown + 0:15



Command Service Module (CSM) Activity

Select P52 (Inertial Measurement Unit (IMU) Realignment program) to pre Powered Descent Initiation (PDI) REFSMMAT

Confirm Stay/No Stay for nominal lunar stay

Receive Lunar Module (LM) position vector on the lunar surface (RLS) and CSM state vector

Select P22 (Landmark Tracking Program) – Sextant (SXT) tracking of landmark