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Volume 2

Thomas Baird

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21TH CENTURY

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Chapter 8

2004 Indian Ocean Earthquake and Tsunami

The **2004 Indian Ocean earthquake and tsunami** (also known as the **Boxing Day Tsunami** and, by the scientific community, the **Sumatra–Andaman earthquake**) occurred at 07:58:53 in local time (UTC+7) on 26 December, with an epicentre off the west coast of northern Sumatra, Indonesia. It was an undersea megathrust earthquake that registered a magnitude of 9.1–9.3 M_w, reaching a Mercalli intensity up to IX in certain areas. The earthquake was caused by a rupture along the fault between the Burma Plate and the Indian Plate.

A series of massive tsunami waves grew up to 30 m (100 ft) high once heading inland, after being created by the underwater seismic activity offshore. Communities along the surrounding coasts of the Indian Ocean were devastated, and the tsunamis killed an estimated 227,898 people in 14 countries, making it one of the deadliest natural disasters in recorded history. The direct results caused major disruptions to living conditions and commerce in coastal provinces of surrounded countries, including Aceh (Indonesia), Sri Lanka, Tamil Nadu (India) and Khao Lak (Thailand). Banda Aceh reported the largest number of deaths.

The earthquake was the third-largest ever recorded, the largest in the 21st century and had the longest duration of faulting ever observed, between eight and ten minutes. It caused the

planet to vibrate as much as 10 mm (0.4 in), and also remotely triggered earthquakes as far away as Alaska. Its epicentre was between Simeulue and mainland Sumatra. The plight of the affected people and countries prompted a worldwide humanitarian response, with donations totalling more than US$14 billion.

Earthquake

The 2004 Indian Ocean earthquake was initially documented as having a moment magnitude of 8.8. In February 2005, scientists revised the estimate of the magnitude to 9.0. Although the Pacific Tsunami Warning Center has accepted these new numbers, the United States Geological Survey has so far not changed its estimate of 9.1. A 2006 study estimated a magnitude of M_w 9.1–9.3; Hiroo Kanamori of the California Institute of Technology estimates that M_w 9.2 is representative of the earthquake's size.

The hypocentre of the main earthquake was approximately 160 km (100 mi) off the western coast of northern Sumatra, in the Indian Ocean just north of Simeulue island at a depth of 30 km (19 mi) below mean sea level (initially reported as 10 km or 6.2 mi). The northern section of the Sunda megathrust ruptured over a length of 1,300 km (810 mi). The earthquake (followed by the tsunami) was felt in Bangladesh, India, Malaysia, Myanmar, Thailand, Sri Lanka and the Maldives. Splay faults, or secondary "pop up faults", caused long, narrow parts of the seafloor to pop up in seconds. This quickly elevated the height and increased the speed of waves, destroying the nearby Indonesian town of Lhoknga.

Indonesia lies between the Pacific Ring of Fire along the north-eastern islands adjacent to New Guinea, and the Alpide belt that runs along the south and west from Sumatra, Java, Bali, Flores to Timor. The 2002 Sumatra earthquake is believed to have been a foreshock, preceding the main event by over two years.

Great earthquakes, such as the 2004 Indian Ocean earthquake, are associated with megathrust events in subduction zones. Their seismic moments can account for a significant fraction of the global seismic moment across century-scale periods. Of all the moment released by earthquakes in the 100 years from 1906 through 2005, roughly one eighth was due to the 2004 Indian Ocean earthquake. This quake, together with the Great Alaskan earthquake (1964) and the Great Chilean earthquake (1960), account for almost half of the total moment.

Since 1900, the only earthquakes recorded with a greater magnitude were the 1960 Valdivia earthquake (magnitude 9.5) and the 1964 Alaska earthquake in Prince William Sound (magnitude 9.2). The only other recorded earthquakes of magnitude 9.0 or greater were off Kamchatka, Russia, on 4 November 1952 (magnitude 9.0) and Tōhoku, Japan (magnitude 9.1) in March 2011. Each of these megathrust earthquakes also spawned tsunamis in the Pacific Ocean. In comparison to the 2004 Indian Ocean earthquake, the death toll from these earthquakes was significantly lower, primarily because of the lower population density along the coasts near affected areas, the much greater distances to more populated coasts, and the superior infrastructure and warning systems in MEDCs (More Economically Developed Countries) such as Japan.

Other huge megathrust earthquakes occurred in 1868 (Peru, Nazca Plate and South American Plate); 1827 (Colombia, Nazca Plate and South American Plate); 1812 (Venezuela, Caribbean Plate and South American Plate) and 1700 (western North America, Juan de Fuca Plate and North American Plate). All of them are believed to be greater than magnitude 9, but no accurate measurements were available at the time.

Tectonic plates

The 2004 Indian Ocean earthquake was unusually large in geographical and geological extent. An estimated 1,600 km (1,000 mi) of fault surface slipped (or ruptured) about 15 m (50 ft) along the subduction zone where the Indian Plate slides (or subducts) under the overriding Burma Plate. The slip did not happen instantaneously but took place in two phases over several minutes: Seismographic and acoustic data indicate that the first phase involved a rupture about 400 km (250 mi) long and 100 km (60 mi) wide, 30 km (19 mi) beneath the sea bed—the largest rupture ever known to have been caused by an earthquake.

The rupture proceeded at about 2.8 km/s (1.7 mi/s; 10,000 km/h; 6,300 mph), beginning off the coast of Aceh and proceeding north-westerly over about 100 seconds. After a pause of about another 100 seconds, the rupture continued northwards towards the Andaman and Nicobar Islands. The northern rupture occurred more slowly than in the south, at about 2.1 km/s (1.3 mi/s; 7,600 km/h; 4,700 mph), continuing north for another five minutes to a plate boundary where the fault type changes from subduction to strike-slip (the two plates slide past one another in opposite directions).

The Indian Plate is part of the great Indo-Australian Plate, which underlies the Indian Ocean and Bay of Bengal, and is moving north-east at an average of 60 mm/a (0.075 in/Ms). The India Plate meets the Burma Plate (which is considered a portion of the great Eurasian Plate) at the Sunda Trench. At this point, the India Plate subducts beneath the Burma Plate, which carries the Nicobar Islands, the Andaman Islands, and northern Sumatra.

The India Plate sinks deeper and deeper beneath the Burma Plate until the increasing temperature and pressure drive volatiles out of the subducting plate. These volatiles rise into the overlying plate, causing partial melting and the formation of magma. The rising magma intrudes into the crust above and exits the Earth's crust through volcanoes in the form of a volcanic arc. The volcanic activity that results as the Indo-Australian Plate subducts the Eurasian Plate has created the Sunda Arc.

As well as the sideways movement between the plates, the 2004 Indian Ocean earthquake resulted in a rise of the seafloor by several metres, displacing an estimated 30 km (7.2 cu mi) of water and triggering devastating tsunami waves. The waves radiated outwards along the entire 1,600 km (1,000 mi) length of the rupture (acting as a line source).

This greatly increased the geographical area over which the waves were observed, reaching as far as Mexico, Chile, and the Arctic. The raising of the seafloor significantly reduced the capacity of the Indian Ocean, producing a permanent rise in the global sea level by an estimated 0.1 mm (0.004 in).

Aftershocks and other earthquakes

Numerous aftershocks were reported off the Andaman Islands, the Nicobar Islands and the region of the original epicentre in the hours and days that followed. The magnitude 8.7 2005 Nias–Simeulue earthquake, which originated off the coast of the Sumatran island of Nias, is not considered an aftershock, despite its proximity to the epicentre, and was most likely triggered by stress changes associated with the 2004 event. The earthquake produced its own aftershocks (some registering a magnitude of as high as 6.1) and presently ranks as the third-largest earthquake ever recorded on the moment magnitude or Richter magnitude scale.

Other aftershocks of up to magnitude 6.6 continued to shake the region daily for three or four months. As well as continuing aftershocks, the energy released by the original earthquake continued to make its presence felt well after the event. A week after the earthquake, its reverberations could still be measured, providing valuable scientific data about the Earth's interior.

The 2004 Indian Ocean earthquake came just three days after a magnitude 8.1 earthquake in the sub-antarctic Auckland Islands, an uninhabited region west of New Zealand, and Macquarie Island to Australia's north. This is unusual since earthquakes of magnitude eight or more occur only about once per year on average. The U.S. Geological Survey sees no evidence of a causal relationship between these events.

The 2004 Indian Ocean earthquake is thought to have triggered activity in both Leuser Mountain and Mount Talang, volcanoes

in Aceh along the same range of peaks, while the 2005 Nias–Simeulue earthquake had sparked activity in Lake Toba, an ancient crater in Sumatra.

Energy released

The energy released on the Earth's surface (M_E, which is the *seismic potential for damage*) by the 2004 Indian Ocean earthquake was estimated at 1.1×10 joules (110 PJ; 26 Mt). This energy is equivalent to over 1,500 times that of the Hiroshima atomic bomb, but less than that of Tsar Bomba, the largest nuclear weapon ever detonated. The total physical work done M_W (and thus energy) by the quake was 4.0×10 joules (40 ZJ), the vast majority underground, which is over 360,000 times more than its M_E, equivalent to 9,600 gigatons of TNT equivalent (550 million times that of Hiroshima) or about 370 years of energy use in the United States at 2005 levels of 1.08×10 joules (108 EJ). The only recorded earthquakes with a larger M_W were the 1960 Chilean and 1964 Alaskan quakes, with 2.5×10 joules (250 ZJ) and 7.5×10 joules (75 ZJ), respectively.

The earthquake generated a seismic oscillation of the Earth's surface of up to 200–300 mm (8–12 in), equivalent to the effect of the tidal forces caused by the Sun and Moon. The seismic waves of the earthquake were felt across the planet; as far away as the U.S. state of Oklahoma, where vertical movements of 3 mm (0.12 in) were recorded. By February 2005, the earthquake's effects were still detectable as a 20 μm (0.02 mm; 0.0008 in) complex harmonic oscillation of the Earth's surface, which gradually diminished and merged with the incessant free oscillation of the Earth more than four months after the

earthquake. Because of its enormous energy release and shallow rupture depth, the earthquake generated remarkable seismic ground motions around the globe, particularly due to huge Rayleigh (surface) elastic waves that exceeded 10 mm (0.4 in) in vertical amplitude everywhere on Earth. The record section plot displays vertical displacements of the Earth's surface recorded by seismometers from the IRIS/USGS Global Seismographic Network plotted with respect to time (since the earthquake initiation) on the horizontal axis, and vertical displacements of the Earth on the vertical axis (note the 1 cm scale bar at the bottom for scale).

The seismograms are arranged vertically by distance from the epicentre in degrees. The earliest, lower amplitude signal is that of the compressional (P) wave, which takes about 22 minutes to reach the other side of the planet (the antipode; in this case near Ecuador). The largest amplitude signals are seismic surface waves that reach the antipode after about 100 minutes. The surface waves can be clearly seen to reinforce near the antipode (with the closest seismic stations in Ecuador), and to subsequently encircle the planet to return to the epicentral region after about 200 minutes. A major aftershock (magnitude 7.1) can be seen at the closest stations starting just after the 200-minute mark. The aftershock would be considered a major earthquake under ordinary circumstances but is dwarfed by the mainshock.

The shift of mass and the massive release of energy slightly altered the Earth's rotation. The exact amount is not yet known, but theoretical models suggest the earthquake shortened the length of a day by 2.68 microseconds, due to a decrease in the oblateness of the Earth. It also caused the

Earth to minutely "wobble" on its axis by up to 25 mm (1 in) in the direction of 145° east longitude, or perhaps by up to 50 or 60 mm (2.0 or 2.4 in). Because of tidal effects of the Moon, the length of a day increases at an average of 15 microseconds per year, so any rotational change due to the earthquake will be lost quickly. Similarly, the natural Chandler wobble of the Earth, which in some cases can be up to 15 m (50 ft), will eventually offset the minor wobble produced by the earthquake.

There was 10 m (33 ft) movement laterally and 4–5 m (13–16 ft) vertically along the fault line. Early speculation was that some of the smaller islands south-west of Sumatra, which is on the Burma Plate (the southern regions are on the Sunda Plate), might have moved south-west by up to 36 m (120 ft), but more accurate data released more than a month after the earthquake found the movement to be about 0.2 m (8 in). Since movement was vertical as well as lateral, some coastal areas may have been moved to below sea level. The Andaman and Nicobar Islands appear to have shifted south-west by around 1.25 m (4 ft 1 in) and to have sunk by 1 m (3 ft 3 in).

In February 2005, the Royal Navy vessel HMS *Scott* surveyed the seabed around the earthquake zone, which varies in depth between 1,000 and 5,000 m (550 and 2,730 fathoms; 3,300 and 16,400 ft). The survey, conducted using a high-resolution, multi-beam sonar system, revealed that the earthquake had made a considerable impact on the topography of the seabed. 1,500-metre-high (5,000 ft) thrust ridges created by previous geologic activity along the fault had collapsed, generating landslides several kilometres wide. One such landslide consisted of a single block of rock some 100 m (330 ft) high

and 2 km (1.2 mi) long. The momentum of the water displaced by tectonic uplift had also dragged massive slabs of rock, each weighing millions of tonnes, as far as 10 km (6 mi) across the seabed. An oceanic trench several kilometres wide was exposed in the earthquake zone.

The TOPEX/Poseidon and Jason-1 satellites happened to pass over the tsunami as it was crossing the ocean. These satellites carry radars that measure precisely the height of the water surface; anomalies in the order of 500 mm (20 in) were measured. Measurements from these satellites may prove invaluable for the understanding of the earthquake and tsunami. Unlike data from tide gauges installed on shores, measurements obtained in the middle of the ocean can be used for computing the parameters of the source earthquake without having to compensate for the complex ways in which proximity to the coast changes the size and shape of a wave.

Tsunami

The sudden vertical rise of the seabed by several metres during the earthquake displaced massive volumes of water, resulting in a tsunami that struck the coasts of the Indian Ocean. A tsunami that causes damage far away from its source is sometimes called a teletsunami and is much more likely to be produced by the vertical motion of the seabed than by horizontal motion.

The tsunami, like all others, behaved differently in deep water than in shallow water. In deep ocean water, tsunami waves form only a low, broad hump, barely noticeable and harmless, which generally travels at high speed of 500 to 1,000 km/h

(310 to 620 mph); in shallow water near coastlines, a tsunami slows down to only tens of kilometres per hour but, in doing so, forms large destructive waves. Scientists investigating the damage in Aceh found evidence that the wave reached a height of 24 m (80 ft) when coming ashore along large stretches of the coastline, rising to 30 m (100 ft) in some areas when travelling inland. Radar satellites recorded the heights of tsunami waves in deep water: maximum height was at 600 mm (2 ft) two hours after the earthquake, the first such observations ever made.

According to Tad Murty, vice-president of the Tsunami Society, the total energy of the tsunami waves was equivalent to about 5 megatons of TNT (21 PJ), which is more than twice the total explosive energy used during all of World War II (including the two atomic bombs) but still a couple of orders of magnitude less than the energy released in the earthquake itself. In many places, the waves reached as far as 2 km (1.2 mi) inland.

Because the 1,600 km (1,000 mi) fault affected by the earthquake was in a nearly north–south orientation, the greatest strength of the tsunami waves was in an east–west direction. Bangladesh, which lies at the northern end of the Bay of Bengal, had few casualties despite being a low-lying country relatively near the epicentre. It also benefited from the fact that the earthquake proceeded more slowly in the northern rupture zone, greatly reducing the energy of the water displacements in that region.

Coasts that have a landmass between them and the tsunami's location of origin are usually safe; however, tsunami waves can sometimes diffract around such landmasses. Thus, the state of Kerala was hit by the tsunami despite being on the western

coast of India, and the western coast of Sri Lanka suffered substantial impacts. Distance alone was no guarantee of safety, as Somalia was hit harder than Bangladesh despite being much farther away.

Because of the distances involved, the tsunami took anywhere from fifteen minutes to seven hours to reach the coastlines. The northern regions of the Indonesian island of Sumatra were hit quickly, while Sri Lanka and the east coast of India were hit roughly 90 minutes to two hours later. Thailand was struck about two hours later despite being closer to the epicentre because the tsunami travelled more slowly in the shallow Andaman Sea off its western coast.

The tsunami was noticed as far as Struisbaai in South Africa, about 8,500 km (5,300 mi) away, where a 1.5-metre-high (5 ft) tide surged on shore about 16 hours after the earthquake. It took a relatively long time to reach Struisbaai at the southernmost point of Africa, probably because of the broad continental shelf off South Africa and because the tsunami would have followed the South African coast from east to west. The tsunami also reached Antarctica, where tidal gauges at Japan's Showa Base recorded oscillations of up to a metre (3 ft 3 in), with disturbances lasting a couple of days.

Some of the tsunami's energy escaped into the Pacific Ocean, where it produced small but measurable tsunamis along the western coasts of North and South America, typically around 200 to 400 mm (7.9 to 15.7 in). At Manzanillo, Mexico, a 2.6 m (8.5 ft) crest-to-trough tsunami was measured. As well, the tsunami was large enough to be detected in Vancouver, which puzzled many scientists, as the tsunamis measured in some

parts of South America were larger than those measured in some parts of the Indian Ocean. It has been theorized that the tsunamis were focused and directed at long ranges by the mid-ocean ridges which run along the margins of the continental plates.

Early signs and warnings

Despite a delay of up to several hours between the earthquake and the impact of the tsunami, nearly all of the victims were taken by surprise. There were no tsunami warning systems in the Indian Ocean to detect tsunamis or to warn the general population living around the ocean. Tsunami detection is not easy because while a tsunami is in deep water, it has little height and a network of sensors is needed to detect it.

Tsunamis are more frequent in the Pacific Ocean than in other oceans because of earthquakes in the "Ring of Fire". Although the extreme western edge of the Ring of Fire extends into the Indian Ocean (the point where the earthquake struck), no warning system exists in that ocean. Tsunamis there are relatively rare despite earthquakes being relatively frequent in Indonesia. The last major tsunami was caused by the 1883 eruption of Krakatoa. Not every earthquake produces large tsunamis: on 28 March 2005, a magnitude 8.7 earthquake hit roughly the same area of the Indian Ocean but did not result in a major tsunami.

The first warning sign of a possible tsunami is the earthquake itself. However, tsunamis can strike thousands of kilometres away where the earthquake is felt only weakly or not at all. Also, in the minutes preceding a tsunami strike, the sea

sometimes recedes temporarily from the coast, which was observed on the eastern earthquake rupture zone such as the coastlines of Aceh, Phuket island, and Khao Lak area in Thailand, Penang island of Malaysia, and the Andaman and Nicobar islands. This rare sight reportedly induced people, especially children, to visit the coast to investigate and collect stranded fish on as much as 2.5 km (1.6 mi) of exposed beach, with fatal results. However, not all tsunamis cause this "disappearing sea" effect. In some cases, there are no warning signs at all: the sea will suddenly swell without retreating, surprising many people and giving them little time to flee.

One of the few coastal areas to evacuate ahead of the tsunami was on the Indonesian island of Simeulue, close to the epicentre. Island folklore recounted an earthquake and tsunami in 1907, and the islanders fled to inland hills after the initial shaking and before the tsunami struck. These tales and oral folklore from previous generations may have helped the survival of the inhabitants. On Maikhao Beach in north Phuket City, Thailand, a 10-year-old British tourist named Tilly Smith had studied tsunamis in geography at school and recognised the warning signs of the receding ocean and frothing bubbles. She and her parents warned others on the beach, which was evacuated safely. John Chroston, a biology teacher from Scotland, also recognised the signs at Kamala Bay north of Phuket, taking a busload of vacationers and locals to safety on higher ground.

Anthropologists had initially expected the aboriginal population of the Andaman Islands to be badly affected by the tsunami and even feared the already depopulated Onge tribe could have been wiped out. Many of the aboriginal tribes

evacuated and suffered fewer casualties, however. Oral traditions developed from previous earthquakes helped the aboriginal tribes escape the tsunami. For example, the folklore of the Onges talks of "huge shaking of ground followed by high wall of water". Almost all of the Onge people seemed to have survived the tsunami.

Indonesia

Aceh:

- The tsunami devastated the coastline of Aceh province, about 20 minutes after the earthquake. Banda Aceh, the closest major city, suffered severe casualties. The sea receded and exposed the seabed, prompting locals to collect stranded fish and explore the area. Local eyewitnesses described three large waves, with the first wave rising gently to the foundation of the buildings, followed minutes later by a sudden withdrawal of the sea near the port of Ulee Lheue. This was succeeded by the appearance of two large black-coloured steep waves which then travelled inland into the capital city as a large turbulent bore. Eyewitnesses described the tsunami as a "black giant", "mountain" and a "wall of water". Video footage revealed torrents of black water, surging by windows of a two-story residential area situated about 3.2 km (2.0 mi) inland. Additionally, amateur footage recorded in the middle of the city captured an approaching black surge flowing down the city streets, full of debris, inundating them.

The level of destruction was extreme on the northwestern areas of the city, immediately inland of the aquaculture ponds, and directly facing the Indian Ocean. The tsunami height was reduced from 12 m (39 ft) at Ulee Lheue to 6 m (20 ft) a further 8 km (5.0 mi) to the north-east. The inundation was observed to extend 3–4 km (1.9–2.5 mi) inland throughout the city. Within 2–3 km (1.2–1.9 mi) of the shoreline, houses, except for strongly-built reinforced concrete ones with brick walls, which seemed to have been partially damaged by the earthquake before the tsunami attack, were swept away or destroyed by the tsunami.

The area toward the sea was wiped clean of nearly every structure, while closer to the river, dense construction in a commercial district showed the effects of severe flooding. The flow depth at the city was just at the level of the second floor, and there were large amounts of debris piled along the streets and in the ground-floor storefronts. In the seaside section of Ulee Lheue, the flow depths were over 9 m (30 ft). Footage showed evidence of back-flowing of the Aceh River, carrying debris and people from destroyed villages at the coast and transporting them up to 40 km (25 mi) inland.

A group of small islands: Weh, Breueh, Nasi, Teunom, Bunta, Lumpat and Batee island lie just north of the capital city. The tsunami reached a run-up of 10–20 m (33–66 ft) on the western shoreline of Breueh Island and Nasi Island. Coastal villages were destroyed by the tsunami waves. On Pulau Weh, the island experienced strong surges in the port of Sabang, yet there was little damage with a reported runup values of 3–5 m (9.8–16.4 ft), most likely due to the island being sheltered from the direct tsunami attack by the islands to the south-west.

Lhoknga is a small coastal community about 13 km (8.1 mi) south-west of Banda Aceh, located on a flat coastal plain in between two rainforest-covered hills, overlooking a large bay and famous for its large swathe of white sandy beach and surfing activities. The locals reported 10 to 12 tsunamis, with the second and third waves being the highest and most destructive. Interview with the locals revealed that the sea temporarily receded and exposed coral reefs. In the distant horizon, gigantic black waves about 30 m (98 ft) high made explosion-like sounds as it broke and approached the shore. The first wave came rapidly landward from the south-west as a turbulent bore about 0.5–2.5 m (1.6–8.2 ft) high. The second and third waves were 15–30 m (49–98 ft) high at the coast and appeared like gigantic surfing waves but "taller than the coconut trees and was like a mountain".

The second wave was the largest; it came from the west-southwest within five minutes of the first wave. The tsunami stranded cargo ships, barges and destroyed a cement mining facility near the Lampuuk coast, where the tsunami reached the fourth level of the building.

Meulaboh, a remote coastal city, was among the hardest hit by the tsunami. The waves arrived after the sea receded about 500 m (1,600 ft), followed by an advancing small tsunami. The second and third destructive waves arrived later, which exceeded the height of the coconut trees. The inundation distance is about 5 km (3.1 mi). Other towns on Aceh's west coast hit by the disaster included Leupung, Lhokruet, Lamno, Patek, Calang, and Teunom. Affected or destroyed towns on the region's north and east coast were Pidie Regency, Samalanga, Panteraja, and Lhokseumawe. The high fatality rate in the area

was mainly due to lack of preparation of the community towards a tsunami and limited knowledge and education among the population regarding the natural phenomenon. Helicopter surveys showed entire settlements virtually destroyed with destruction within miles inland, and only some mosques left standing.

The greatest run-up height of the tsunami was measured at a hill between Lhoknga and Leupung, on the western coast of the northern tip of Sumatra, near Banda Aceh, and reached 51 m (167 ft).

The tsunami heights in Sumatra:

- 15–30 m (49–98 ft) on the west coast of Aceh
- 6–12 m (20–39 ft) on the Banda Aceh coast
- 6 m (20 ft) on the Krueng Raya coast
- 5 m (16 ft) on the Sigli coast
- 3–6 m (9.8–19.7 ft) on the north coast of Weh Island directly facing the tsunami source
- 3 m (9.8 ft) on the opposite side of the coast of Weh Island facing the tsunami

Sri Lanka

The island country of Sri Lanka, located about 1,700 km (1,100 mi) from Sumatra, was ravaged by the tsunami around 2 hours after the earthquake. The tsunami first struck the eastern coastline and subsequently refracted around the southern point of Sri Lanka (Dondra Head). The refracted tsunami waves then inundated the southwestern part of Sri Lanka after some of its energy was reflected from impact with the Maldives. In Sri Lanka, the civilian casualties were second

only to those in Indonesia, with approximately 35,000 killed by the tsunami. The eastern shores of Sri Lanka were the hardest hit since it faced the epicentre of the earthquake, while the southwestern shores were hit later, but the death toll was just as severe. The southwestern shores are a hotspot for tourists and fishing. The degradation of the natural environment in Sri Lanka contributed to the high death tolls. Approximately 90,000 buildings and many wooden houses were destroyed.

The tsunami arrived on the island as a small brown-orange colored flood. Moments later, the ocean floor was exposed to as much as 1 km (0.62 mi) in places, which was followed by a massive second and third tsunami wave. Amateur video recorded at the city of Galle showed a large deluge flooding the city, carrying debris and sweeping away people while in the coastal resort town of Beruwala, the tsunami appeared as a huge brown-orange colored bore which reached the first level of a hotel, causing destruction and taking people unaware. Other videos recorded showed that the tsunami appeared like a flood raging inland. The construction of seawalls and breakwaters reduced the power of waves at some locations.

The largest run-up measured was at 12.5 m (41 ft) with inundation distance of 390–1,500 m (1,280–4,920 ft) in Yala. In Hambantota, tsunami run-ups measured 11 m (36 ft) with the greatest inundation distance of 2 km (1.2 mi). Tsunami run-up measurements along the Sri Lankan coasts are at 2.4–4.11 m (7 ft 10 in–13 ft 6 in). Tsunami waves measured on the east coast ranged from 4.5–9 m (15–30 ft) at Pottuvill to Batticaloa at 2.6–5 m (8 ft 6 in–16 ft 5 in) in the north-east around Trincomalee and 4–5 m (13–16 ft) in the west coast from Moratuwa to Ambalangoda.

Sri Lanka tsunami height survey:

- 9 m (30 ft) at Koggala
- 6 m (20 ft) at Galle port
- 4.8 m (16 ft) around the Galle coast
- 8.7 m (29 ft) at Nonagama
- 4.9 m (16 ft) at Weligama
- 4 m (13 ft) at Dodundawa
- 4.7 m (15 ft) at Ambalangoda
- 4.7 m (15 ft) at Hikkaduwa Fishery Harbour
- 10 m (33 ft) at Kahawa
- 4.8 m (16 ft) at North Beach of Beruwala
- 6 m (20 ft) at Paiyagala

A regular passenger train operating between Maradana and Matara was derailed and overturned by the tsunami and claimed at least 1,700 lives, the largest single rail disaster death toll in history. Estimates based on the state of the shoreline and a high-water mark on a nearby building place the tsunami 7.5–9 m (25–30 ft) above sea level and 2–3 m (6 ft 7 in–9 ft 10 in) higher than the top of the train.

Thailand

The tsunami travelled eastward through the Andaman Sea and hit the south-western coasts of Thailand, about 2 hours after the earthquake. Located about 500 km (310 mi) from the epicentre, at the time, the region was popular with tourists because of Christmas. Many of these tourists were caught off-guard by the tsunami, as they had no prior warning. The tsunami hit during high tide. Major locations damaged included the western shores of Phuket island, the resort town

of Khao Lak in Phang Nga Province, the coastal provinces of Krabi, Satun, Ranong and Trang and small offshore islands like Ko Racha Yai, the Phi Phi islands, the Surin Islands and the Similan archipelago. Approximately 8,000 people were killed.

Thailand experienced the second largest tsunami run-up. The tsunami heights recorded:

- 6–10 m (20–33 ft) in Khao Lak
- 3–6 m (9.8–19.7 ft) along the west coast of Phuket island
- 3 m (9.8 ft) along the south coast of Phuket island
- 2 m (6 ft 7 in) along the east coast of Phuket island
- 4–6 m (13–20 ft) on the Phi Phi Islands
- 19.6 m (64 ft) at Ban Thung Dap
- 5 m (16 ft) at Ramson
- 6.8 m (22 ft) at Ban Thale Nok
- 5 m (16 ft) at Hat Praphat (Ranong Coastal Resources Research Station)
- 6.3 m (21 ft) at Thai Mueang District
- 6.8 m (22 ft) at Rai Dan

The province of Phang Nga was the most affected area in Thailand. The quiet resort town of Khao Lak is located on a stretch of golden sandy beach, famed for its hotels overlooking the Andaman Sea and hilly rainforests. A video, taken by a local restaurant manager from a hill adjacent to the beach, showed that the tsunami's arrival was preceded by a sudden retreat of the sea exposing the seafloor. Many tourists and locals can be seen trying to gather fish. Moments later, the tsunami arrives as a wall of foaming water that slams into the

coast, washing away numerous people who had no time to escape. Another amateur video, captured by a German family at beach level, showed the tsunami appearing as a white horizontal line in the distant horizon, gradually becoming bigger (bore-like), engulfing a jet skier and lifting two police boats. A maximum inundation of approximately 2 km (1.2 mi) was measured, the inundated depths were 4–7 m (13–23 ft) and there was evidence that the tsunami reached the third floor of a resort hotel. The tsunami in Khao Lak was bigger due to offshore coral reefs and shallow seafloor which caused the tsunami to pile-up. This was similar to eyewitness accounts of the tsunami at Banda Aceh.

Khao Lak also experienced the largest tsunami run-up height outside of Sumatra.. The highest-recorded tsunami run-up was measured 19.6 m (64 ft) at Ban Thung Dap, on the south-west tip of Ko Phra Thong Island and the second-highest at 15.8 m (52 ft) at Ban Nam Kim. Moreover, the largest death toll occurred at Khao Lak, with about 5,000 people killed.

In addition, the tsunami inflicted damage to the popular resort town of Ao Nang in Krabi Province. Video footage showed that the tsunami appeared as multiple white surfs violently lifting up yachts, boats and crashing onto beaches.

Footage captured at Koh Lanta showed a wall of water swamping the beach, while another video taken at another location showed a large surfing wave like tsunami approaching the shore, lifting up a yacht and flooding the beach. At Koh Sriboya, the tsunami advanced inland as a turbulent medium bore, while at Koh Phayam, Ranong Province, the tsunami appeared as a wall of water.

At Phuket Province, the island province's western beaches were struck by the tsunami. At Patong Beach, a tourist mecca, the tsunami first arrived as a small flood, which swept away cars and unexpected people. About 10 minutes later, the sea receded for a while before the tsunami arrived again as a large wall of water looming over the skyline and flooding the coast. Another video from Kamala Beach showed the tsunami flooding the ground floor of a restaurant sweeping away an elderly couple. On Karon Beach, Kamala Beach and Kata Beach, the tsunami came in like a surging flood inland carrying people and cars. On some locations, a coastal road was built which was higher than the shore, protecting a hotel which was behind it. On the east coast of Phuket Island, the tsunami height was about 2 m. In one river mouth, many boats were damaged.

The tsunami moved counter-clockwise around Phuket Island, as was the case at Okushiri Island in the 1993 Hokkaido earthquake. According to interviews, the second wave was the largest. The tsunami heights were 5–6 m (16–20 ft) and the inundated depth was about 2 m (6.6 ft). The tsunami surprised many tourists at Koh Racha Yai, where it flooded the resorts. About 250 people perished directly in the tsunami.

The Phi Phi Islands are a group of small islands that were affected by the tsunami. The north bay of Phi Phi Don Island opens to the north-west in the direction of the tsunami. The measured tsunami height on this beach was 5.8 m (19 ft). According to eyewitness accounts, the tsunami came from the north and south. The ground level was about 2 m above sea level, where there were many cottages and hotels. The south bay opens to the south-east and faces in the opposite direction

from the tsunami. Furthermore, Phi Phi Le Island shields the port of Phi Phi Don Island. The measured tsunami height was 4.6 m (15 ft) in the port. Amateur camcorder footage taken by Israeli tourists showed the tsunami advancing inland suddenly as a small flood, gradually becoming more powerful and engulfing the whole beach and resort, with the tsunami carrying a yacht out to sea.

Moreover, the tsunami was detected by scuba divers around offshore islands like the Similan Islands and the Surin Islands. The divers reported being caught in a violent, swirling current suddenly while underwater. Local camcorder footage showed the tsunami surging inland and flooding camping equipment at the Similan Islands while the tsunami caught tourists unaware at the Surin Islands, and dragging them out towards the sea.

India

The tsunami reached the states of Andhra Pradesh and Tamil Nadu along the southeastern coastline of the Indian mainland about 2 hours after the earthquake. At the same time, it arrived in the state of Kerala, on the southwestern coast. There were two to five tsunamis that coincided with the local high tide in some areas.

The tsunami runup height measured in mainland India by Ministry of Home Affairs includes:

- 3.4 m (11 ft) at Kerala, inundation distance of 0.5–1.5 km (0.31–0.93 mi) with 250 km (160 mi) of coastline affected

- 4.5 m (15 ft) at the southern coastline of Tamil Nadu, inundation distance of 0.2–2 km (0.12–1.24 mi) with 100 km (62 mi) of coastline affected
- 5 m (16 ft) at the eastern coastline of Tamil Nadu facing tsunami source, inundation distance of 0.4–1.5 km (0.25–0.93 mi) with 800 km (500 mi) of coastline affected
- 4 m (13 ft) at Pondicherry, inundation distance of 0.2–2 km (0.12–1.24 mi) with 25 km (16 mi) of coastline affected
- 2.2 m (7.2 ft) at Andhra Pradesh, inundation distance of 0.2–1 km (0.12–0.62 mi) with 985 km (612 mi) of coastline affected

Along the coast of Tamil Nadu, the 13 km (8.1 mi) Marina Beach in Chennai was battered by the tsunami which swept across the beach taking morning walkers unaware. Amateur video recorded taken at a resort beach showed the tsunami arriving as a large wall of water as it approached the coast and flooding it as it advanced inland. Besides that, a 10 m (33 ft) black muddy tsunami ravaged the city of Karaikal, where 492 lives were lost.

The city of Pondicherry, protected by seawalls was relatively unscathed. Local video recorded that before the arrival of the tsunami, people can be seen swarming the beach to check on stranded fish from the exposed beach. Furthermore, at the coastal town of Kanyakumari, the seabed was exposed briefly before a large wall of water can be seen on the horizon and subsequently flooding the town. Other footage showed the tsunami dramatically crashed into the Vivekananda Rock Memorial. The worst affected area in Tamil Nadu was

Nagapattinam district, with 6,051 fatalities caused by a 5 m (16 ft) tsunami, followed by Cuddalore district, with many villages destroyed. Most of the people killed were members of the fishing community.

The state of Kerala experienced tsunami-related damage in three southern densely populated districts, Ernakulam, Alappuzha, and Kollam, due to diffraction of the waves around Sri Lanka. The southernmost district of Thiruvananthpuram, however, escaped damage, possibly due to the wide turn of the diffracted waves at the peninsular tip. Major damage occurred in two narrow strips of land bound on the west by the Arabian Sea and on the east by the Kerala backwaters. The waves receded before the first tsunami with the highest fatality reported from the densely populated Alappad panchayat (including the villages of Cheriya Azhikkal and Azhikkal) at Kollam district, caused by a 4 m (13 ft) tsunami. A video recorded by locals showed the tsunami flooding the beach and villages causing despair amongst the villagers.

Many villages in the state of Andhra Pradesh were destroyed. In the Krishna district, the tsunami created havoc in Manginapudi and on Machalipattanam Beach. The most affected was Prakasham District, recording 35 deaths, with maximum damage at Singraikonda. Given the enormous power of the tsunami, the fishing industry suffered the greatest. Moreover, the cost of damage in the transport sector was reported in the tens of thousands.

The tsunami run-up was only 1.6 m (5.2 ft) in areas in the state of Tamil Nadu shielded by the island of Sri Lanka but was 4–5 m (13–16 ft) in coastal districts such as Nagapattinam

in Tamil Nadu directly across from Sumatra. On the western coast, the runup elevations were 4.5 m (15 ft) at Kanyakumari District in Tamil Nadu and 3.4 m (11 ft) each at Kollam and Ernakulam districts in Kerala. The time between the waves ranged from about 15 minutes to 90 minutes. The tsunami varied in height from 2 m (6.6 ft) to 10 m (33 ft) based on survivors' accounts. The tsunami travelled 2.5 km (1.6 mi) at its maximum inland at Karaikal, Puducherry. The inundation distance varied between 1,006–500 m (3,301–1,640 ft) in most areas, except at river mouths, where it was more than 1 km (0.62 mi). Areas with dense coconut groves or mangroves had much smaller inundation distances, and those with river mouths or backwaters saw larger inundation distances. Presence of seawalls at the Kerala and Tamil Nadu coasts reduced the impact of the waves. However, when the seawalls were made of loose stones, the stones were displaced and carried a few metres inland.

Andaman and Nicobar Islands

Due to close proximity to the earthquake, the tsunami took just minutes to devastate the Andaman and Nicobar Islands. The Andaman Islands were moderately affected while the island of Little Andaman and the Nicobar Islands were severely affected by the tsunami.

In South Andaman island, based on local eyewitnesses, there were three tsunami waves, with the third being the most destructive. Flooding occurred at the coast and low-lying areas inland, which were connected to open sea through creeks. Inundation was observed, along the east coast of South Andaman Island, restricted to Chidiyatapu, Burmanallah,

Kodiaghat, Beadnabad, Corbyn's cove and Marina Park/Aberdeen Jetty areas. Along the west coast, the inundation was observed around Guptapara, Manjeri, Wandoor, Collinpur and Tirur regions. Several near-shore establishments and numerous infrastructures such as seawalls and a 20 MW diesel-generated power plant at Bamboo Flat were destroyed. At Port Blair, the water receded before the first wave, and the third wave was the tallest and caused the most damage.

Results of the tsunami survey in South Andaman along Chiriyatapu, Corbyn's Cove and Wandoor beaches:

- 5 m (16 ft) in maximum tsunami height with a run-up of 4.24 m (13.9 ft) at Chiriyatapu Beach
- 5.5 m (18 ft) in maximum tsunami height and run-up at Corbyn's Cove Beach
- 6.6 m (22 ft) in maximum tsunami height and run-up of 4.63 m (15.2 ft) at Wandoor Beach

Meanwhile, in the Little Andaman, tsunami waves impinged on the eastern shore about 25 to 30 minutes after the earthquake in a four-wave cycle of which the fourth tsunami was the most devastating with a wave height of about 10 m (33 ft). The tsunami destroyed settlements at Hut Bay within a range of 1 km (0.62 mi) from the seashore. Run up level up to 3.8 m (12 ft) have been measured.

In Malacca, located on the island of Car Nicobar, there were three tsunami waves. The sea was observed to rise suddenly before the onset of the first wave. The first wave came 5 minutes after the earthquake, preceded by a recession of the sea up to 600–700 m (2,000–2,300 ft).. The second and third

waves came in 10 minutes intervals after the first wave. The third wave was the strongest, with a maximum tsunami wave height of 11 m (36 ft). Waves nearly three stories high devastated the Indian Air Force base, located just south of Malacca. The maximum tsunami wave height of 11 m (36 ft). Inundation limit was found to be up to 1.25 km (0.78 mi) inland. The impact of the waves was so severe that four oil tankers were thrown almost 800 m (2,600 ft) from the seashore near Malacca to the Air force colony main gate. In Chuckchucha and Lapati, the tsunami arrived in a three-wave cycle with a maximum tsunami wave height of 12 m (39 ft).

In Campbell Bay of Great Nicobar Island, the tsunami waves hit the area three times with an inundation limit of 250–500 m (820–1,640 ft). A rise in sea level was observed before the first wave came within 5 minutes of the earthquake. The second and third waves came in 10-minute intervals after the first. The second wave was the strongest. The tsunami waves wreaked havoc in the densely populated Jogindar Nagar area, situated 13 km (8.1 mi) south of Campbell Bay. According to local accounts, tsunami waves attacked the area three times. The first wave came five minutes after the mainshock (0629 hrs.) with a marginal drop in sea level. The second wave came 10 minutes after the first one with a maximum height of 4.8 m (16 ft) to 8 m (26 ft) and caused the major destruction. The third wave came within 15 minutes after the second with lower wave height. The maximum inundation limit due to tsunami water was about 500 m (1,600 ft).

The worst affected island in the Andaman & Nicobar chain is Katchall Island, with 303 people confirmed dead and 4,354 missing out of a total population of 5,312. The significant

shielding of Port Blair and Campbell Bay by steep mountainous outcrops contributed to the relatively low wave heights at these locations, whereas the open terrain along the eastern coast at Malacca and Hut Bay contributed to the great height of the tsunami waves.

Reports of tsunami wave height:

- 1.5 m (4 ft 11 in) at Diglipur and Rangat at North Andaman Island
- 8 m (26 ft) high at Campbell Bay on Great Nicobar Island
- 10–12 m (33–39 ft) high at Malacca (in Car Nicobar Island) and at Hut Bay on Little Andaman Island
- 3 m (9.8 ft) high at Port Blair on South Andaman Island

Maldives

The tsunami severely affected the Maldives at a distance of 2,500 km (1,600 mi) from the epicentre. Similar to Sri Lanka, survivors reported three waves with the second wave being the most powerful. Being rich in coral reefs, the Maldives provides an opportunity for scientists to assess the impact of a tsunami on coral atolls.

The significantly lower tsunami impact on the Maldives compared to Sri Lanka is mostly due to the topography and bathymetry of the atoll chain with offshore coral reefs, deep channels separating individual atolls and its arrival within low tide which decreased the power of the tsunami. After the tsunami, there was some concern that the country might be submerged entirely and become uninhabitable. However, this

was proven untrue. The highest tsunami wave measured was 4 m (13 ft) at Vilufushi Island. The tsunami arrived approximately 2 hours after the earthquake. The greatest tsunami inundation occurred at North Male Atoll, Male island at 250 m (820 ft) along the streets.

Local footage recorded showed the tsunami flooding the streets up to knee level in town, while another video taken at the beach showed the tsunami slowly flooding and gradually surging inland.

The Maldives tsunami wave analysis:

- 1.3–2.4 m (4 ft 3 in–7 ft 10 in) at North Male Atoll, Male Island
- 2 m (6 ft 7 in) at North Male Atoll, Huhule Island
- 1.7–2.8 m (5 ft 7 in–9 ft 2 in) at South Male Atoll, Embudhu Finothu
- 2.5–3.3 m (8 ft 2 in–10 ft 10 in) at Laamu Atoll, Fonadhoo Island
- 2.2–2.9 m (7 ft 3 in–9 ft 6 in) at Laamu Atoll, Gan Island
- 2.3–3 m (7 ft 7 in–9 ft 10 in) at North Male Atoll, Dhiffushi Island
- 2.2–2.4 m (7 ft 3 in–7 ft 10 in) at North Male Atoll, Huraa Island
- more than 1.5 m (4 ft 11 in) at North Male Atoll, Kuda Huraa Island

Myanmar

In Myanmar, the tsunami caused only moderate damage, which arrived between 2 and 5.5 hours after the earthquake.

Although the country's western Andaman Sea coastline lies at the proximity of the rupture zone, there were smaller tsunamis than the neighbouring Thai coast, because the main tsunami source did not extend to the Andaman Islands. Another factor is that some coasts of Taninthayi Division were protected by the Myeik Archipelago. Based on scientific surveys from Ayeyarwaddy Delta through Taninthayi Division, it was revealed that tsunami heights along the Myanmar coast were between 0.4–2.9 m (1 ft 4 in–9 ft 6 in). Eyewitnesses compared the tsunami with the "rainy-season high tide"; although at most locations, the tsunami height was similar or smaller than the "rainy-season high tide" level.

Tsunami survey heights:

- 0.6–2.3 m (2 ft 0 in–7 ft 7 in) around the Ayeyarwady delta
- 0.9–2.9 m (2 ft 11 in–9 ft 6 in) at Dawei area
- 0.7–2.2 m (2 ft 4 in–7 ft 3 in) around Myeik
- 0.4–2.6 m (1 ft 4 in–8 ft 6 in) around Kawthaung

Interviews with local people indicate that they did not feel the earthquake in Taninthayi Division or Ayeyarwaddy Delta. The 71 casualties can be attributed to poor housing infrastructure and additionally, the fact that the coastal residents in the surveyed areas live on flat land along the coast, especially in the Ayeyarwaddy Delta, and that there is no higher ground to which to evacuate. The tsunami heights from the 2004 December earthquake were not more than 3 m (9.8 ft) along the Myanmar coast, the amplitudes were slightly large off the Ayeyarwaddy Delta, probably because the shallow delta caused a concentration in tsunami energy.

Somalia

The tsunami travelled 5,000 km (3,100 mi) west across the open ocean before striking the East African country of Somalia. Around 289 fatalities were reported in the Horn of Africa, drowned by four tsunami waves. The hardest-hit was a 650 km (400 mi) stretch of the Somalia coastline between Garacad (Mudug region) and Xaafuun (Bari region), which forms part of the Puntland province.

Most of the victims were reported along the low-lying Xaafuun Peninsula. The Puntland coast in northern Somalia was by far the area hardest hit by the waves to the west of the Indian subcontinent. The waves arrived around noon local time.

Consequently, tsunami runup heights vary from 5 m (16 ft) to 9 m (30 ft) with inundation distances varying from 44 m (144 ft) to 704 m (2,310 ft).

The maximum runup height of almost 9 m (30 ft) was recorded in Bandarbeyla. An even higher runup point was measured on a cliff near the town of Eyl, solely on an eyewitness account.

The highest death toll was in Hafun, with 19 dead and 160 people presumed missing out of its 5,000 inhabitants. This was the highest number of casualties in a single African town and the largest tsunami death toll in a single town to the west of the Indian subcontinent. In Xaafuun, small drawbacks were observed before the third and most powerful tsunami wave flooded the town.

Other locations

The tsunami also reached Malaysia, mainly on the northern states such as Kedah, Perak and Penang and on offshore islands such as Langkawi island. Peninsular Malaysia was shielded by the full force of the tsunami due to the protection offered by the island of Sumatra, which lies just off the western coast.

Bangladesh escaped major damage and deaths because the water displaced by the strike-slip fault was relatively little on the northern section of the rupture zone, which ruptured slowly. In Yemen, the tsunami killed two people with a maximum runup of 2 m (6.6 ft). The tsunami was detected in the southern parts of east Africa, where rough seas were reported, specifically on the eastern and southern coasts that face the Indian Ocean. A few other African countries also recorded fatalities; one in Kenya, three in Seychelles, ten in Tanzania, and South Africa, where two were killed as a direct result of the tsunami—the furthest from the epicentre.

Tidal surges also occurred along the Western Australian coast that lasted for several hours, resulting in boats losing their moorings and two people needing to be rescued.

Impact

Countries affected

According to the U.S. Geological Survey, a total of 227,898 people died. Measured in lives lost, this is one of the ten worst earthquakes in recorded history, as well as the single worst

tsunami in history. Indonesia was the worst affected area, with most death toll estimates at around 170,000. An initial report by Siti Fadilah Supari, the Indonesian Minister of Health at the time, estimated the death total to be as high as 220,000 in Indonesia alone, giving a total of 280,000 fatalities. However, the estimated number of dead and missing in Indonesia were later reduced by over 50,000. In their report, the Tsunami Evaluation Coalition stated, "It should be remembered that all such data are subject to error, as data on missing persons especially are not always as good as one might wish". A much higher number of deaths has been suggested for Myanmar based on reports from Thailand.

The tsunami caused severe damage and deaths as far as the east coast of Africa, with the furthest recorded fatality directly attributed to the tsunami at Rooi-Els, close to Cape Town, 8,000 km (5,000 mi) from the epicentre. In total, eight people in South Africa died due to high sea levels and waves.

Relief agencies reported that one third of the dead appeared to be children. This was a result of the high proportion of children in the populations of many of the affected regions and because children were the least able to resist being overcome by the surging waters. Oxfam went on to report that as many as four times more women than men were killed in some regions because they were waiting on the beach for the fishers to return and looking after their children in the houses.

States of emergency were declared in Sri Lanka, Indonesia, and the Maldives. The United Nations estimated at the outset that the relief operation would be the costliest in human history. Then-UN Secretary-General Kofi Annan stated that

reconstruction would probably take between five and ten years. Governments and non-governmental organizations feared that the final death toll might double as a result of diseases, prompting a massive humanitarian response.

In addition to a large number of local residents, up to 9,000 foreign tourists (mostly Europeans) enjoying the peak holiday travel season were among the dead or missing, especially people from the Nordic countries. The European nation hardest hit was Sweden, with a death toll of 543. Germany was close behind with 539 identified victims.

Economic impact

The level of damage to the economy resulting from the tsunami depends on the scale examined. While local economies were devastated, the overall impact on the national economies was minor. The two main occupations affected by the tsunami were fishing and tourism.

The impact on coastal fishing communities and the people living there, some of the poorest in the region, has been devastating with high losses of income earners as well as boats and fishing gear.

In Sri Lanka artisanal fishery, where the use of fish baskets, fishing traps, and spears are commonly used, is an important source of fish for local markets; industrial fishery is the major economic activity, providing direct employment to about 250,000 people. In recent years the fishery industry has emerged as a dynamic export-oriented sector, generating substantial foreign exchange earnings. Preliminary estimates indicate that 66% of the fishing fleet and industrial

infrastructure in coastal regions have been destroyed by the wave surges, which will have adverse economic effects both at local and national levels.

While the tsunami destroyed many of the boats vital to Sri Lanka's fishing industry, it also created a demand for fibreglass reinforced plastic catamarans in boatyards of Tamil Nadu. Since over 51,000 vessels were lost to the tsunami, the industry boomed. However, the huge demand has led to lower quality in the process, and some important materials were sacrificed to cut prices for those who were impoverished by the tsunami.

Some economists believe that damage to the affected national economies will be minor because losses in the tourism and fishing industries are a relatively small percentage of the GDP. However, others caution that damage to infrastructure is an overriding factor. In some areas drinking water supplies and farm fields may have been contaminated for years by saltwater from the ocean. Even though only coastal regions were directly affected by the waters of the tsunami, the indirect effects have spread to inland provinces as well. Since the media coverage of the event was so extensive, many tourists cancelled vacations and trips to that part of the world, even though their travel destinations may not have been affected. This ripple effect could especially be felt in the inland provinces of Thailand, such as Krabi, which acted as a starting point for many other tourist destinations in Thailand.

Both the earthquake and the tsunami may have affected shipping in the Malacca Straits, which separate Malaysia and the Indonesian island of Sumatra, by changing the depth of the

seabed and by disturbing navigational buoys and old shipwrecks. In one area of the Strait, water depths were previously up to 1,200 m (4,000 ft), and are now only 30 m (100 ft) in some areas, making shipping impossible and dangerous. These problems also made the delivery of relief aid more challenging. Compiling new navigational charts may take months or years. However, officials hope that piracy in the region will drop off as a result of the tsunami.

Countries in the region appealed to tourists to return, pointing out that most tourist infrastructure is undamaged. However, tourists were reluctant to do so for psychological reasons. Even beach resorts in parts of Thailand which were untouched by the tsunami were hit by cancellations.

Environmental impact

Beyond the heavy toll on human lives, the Indian Ocean earthquake has caused an enormous environmental impact that will affect the region for many years to come. It has been reported that severe damage has been inflicted on ecosystems such as mangroves, coral reefs, forests, coastal wetlands, vegetation, sand dunes and rock formations, animal and plant biodiversity and groundwater. Also, the spread of solid and liquid waste and industrial chemicals, water pollution and the destruction of sewage collectors and treatment plants threaten the environment even further, in untold ways. The environmental impact will take a long time and significant resources to assess.

According to specialists, the main effect is being caused by poisoning of the freshwater supplies and of the soil by

saltwater infiltration and a deposit of a salt layer over arable land. It has been reported that in the Maldives, 16 to 17 coral reef atolls that were overcome by sea waves are without fresh water and could be rendered uninhabitable for decades. Uncountable wells that served communities were invaded by sea, sand, and earth; and aquifers were invaded through porous rock. Salted-over soil becomes sterile, and it is difficult and costly to restore for agriculture. It also causes the death of plants and important soil micro-organisms. Thousands of rice, mango, and banana plantations in Sri Lanka were destroyed almost entirely and will take years to recover. On the island's east coast, the tsunami contaminated wells on which many villagers relied for drinking water.

The Colombo-based International Water Management Institute monitored the effects of saltwater and concluded that the wells recovered to pre-tsunami drinking water quality one-and-a-half years after the event. The IWMI developed protocols for cleaning wells contaminated by saltwater; these were subsequently officially endorsed by the World Health Organization as part of its series of Emergency Guidelines.

The United Nations Environment Programme (UNEP) is working with governments of the region in order to determine the severity of the ecological impact and how to address it. UNEP has decided to earmark a US$1 million emergency fund and to establish a Task Force to respond to requests for technical assistance from countries affected by the tsunami.

In response to a request from the Maldivian Government, the Australian Government sent ecological experts to help restore marine environments and coral reefs—the lifeblood of

Maldivian tourism. Much of the ecological expertise has been rendered from work with the Great Barrier Reef, in Australia's northeastern waters.

Historical context

The last major tsunami in the Indian Ocean was about A.D. 1400. In 2008, a team of scientists working on Phra Thong, a barrier island along the hard-hit west coast of Thailand, reported evidence of at least three previous major tsunamis in the preceding 2,800 years, the most recent from about 700 years ago. A second team found similar evidence of previous tsunamis in Aceh, a province at the northern tip of Sumatra; radiocarbon dating of bark fragments in the soil below the second sand layer led the scientists to estimate that the most recent predecessor to the 2004 tsunami probably occurred between A.D. 1300 and 1450.

The 2004 earthquake and tsunami combined is the world's deadliest natural disaster since the 1976 Tangshan earthquake. The earthquake was the third-most-powerful earthquake recorded since 1900. The deadliest-known earthquake in history occurred in 1556 in Shaanxi, China, with an estimated death toll of 830,000, though figures from this period may not be as reliable.

Before 2004, the tsunami created in both Indian and Pacific Ocean waters by the 1883 eruption of Krakatoa, thought to have resulted in anywhere from 36,000 to 120,000 deaths, had probably been the deadliest in the region. In 1782, about 40,000 people are thought to have been killed by a tsunami (or a cyclone) in the South China Sea. The deadliest tsunami

before 2004 was Italy's 1908 Messina earthquake on the Mediterranean Sea where the earthquake and tsunami killed about 123,000.

Other effects

Many health professionals and aid workers have reported widespread psychological trauma associated with the tsunami. Traditional beliefs in many of the affected regions state that a relative of the family must bury the body of the dead, and in many cases, no body remained to be buried. Women in Aceh required a special approach from foreign aid agencies, and continue to have unique needs.

The hardest-hit area, Aceh, is a religiously conservative Islamic society and has had no tourism nor any Western presence in recent years due to the insurgency between the Indonesian military and Free Aceh Movement (GAM). Some believe that the tsunami was divine punishment for lay Muslims shirking their daily prayers or following a materialistic lifestyle. Others have said that Allah was angry that Muslims were killing each other in an ongoing conflict. Saudi cleric Muhammad Al-Munajjid attributed it to divine retribution against non-Muslim vacationers "who used to sprawl all over the beaches and in pubs overflowing with wine" during Christmas break.

The widespread devastation caused by the tsunami led GAM to declare a cease-fire on 28 December 2004 followed by the Indonesian government, and the two groups resumed long-stalled peace talks, which resulted in a peace agreement signed 15 August 2005. The agreement explicitly cites the tsunami as a justification.

In a poll conducted in 27 countries, 15% of respondents named the tsunami the most significant event of the year. Only the Iraq War was named by as many respondents.

The extensive international media coverage of the tsunami, and the role of mass media and journalists in reconstruction, were discussed by editors of newspapers and broadcast media in tsunami-affected areas, in special video-conferences set up by the Asia Pacific Journalism Centre.

The tsunami left both the people and government of India in a state of heightened alert. On 30 December 2004, four days after the tsunami, Terra Research notified the India government that its sensors indicated there was a possibility of 7.9 to 8.1 magnitude tectonic shift in the next 12 hours between Sumatra and New Zealand. In response, the Indian Minister of Home Affairs announced that a fresh onslaught of deadly tsunami was likely along the southern Indian coast and the Andaman and Nicobar Islands, even as there was no sign of turbulence in the region. The announcement generated panic in the Indian Ocean region and caused thousands to flee their homes, which resulted in jammed roads. The announcement was a false alarm, and the Home Affairs minister withdrew their announcement.

On further investigation, the India government learned that the consulting company Terra Research was run from the home of a self-described earthquake forecaster who had no telephone listing and maintained a website where he sold copies of his detection system.

The tsunami had a severe humanitarian and political impact in Sweden. The hardest-hit country outside Asia, Sweden, lost

543 tourists, mainly in Thailand. The Persson Cabinet was heavily criticized for its inaction. Smith Dharmasaroja, a meteorologist who had predicted that an earthquake and tsunami "is going to occur for sure" way back in 1994, was assigned the development of the Thai tsunami warning system. The Indian Ocean Tsunami warning system was formed in early 2005 to provide an early warning of tsunamis for inhabitants around the Indian Ocean coasts.

The changes in the distribution of masses inside the Earth due to the earthquake had several consequences. It displaced the North Pole by 25 mm (0.98 in). It also slightly changed the shape of the Earth, specifically by decreasing Earth's oblateness by about one part in 10 billion, consequentially increasing Earth's rotation a little and thus shortening the length of the day by 2.68 microseconds.

Humanitarian response

A great deal of humanitarian aid was needed because of widespread damage to the infrastructure, shortages of food and water, and economic damage. Epidemics were of particular concern due to the high population density and tropical climate of the affected areas. The main concern of humanitarian and government agencies was to provide sanitation facilities and fresh drinking water to contain the spread of diseases such as cholera, diphtheria, dysentery, typhoid and hepatitis A and hepatitis B.

There was also a great concern that the death toll could increase as disease and hunger spread. However, because of the initial quick response, this was minimized.

In the days following the tsunami, significant effort was spent in burying bodies hurriedly due to fear of disease spreading. However, the public health risks may have been exaggerated, and therefore this may not have been the best way to allocate resources. The World Food Programme provided food aid to more than 1.3 million people affected by the tsunami.

- Nations all over the world provided over US$14 billion in aid for damaged regions, with the governments of Australia pledging US$819.9 million (including a US$760.6 million aid package for Indonesia), Germany offering US$660 million, Japan offering US$500 million, Canada offering US$343 million, Norway and the Netherlands offering both US$183 million, the United States offering US$35 million initially (increased to US$350 million), and the World Bank offering US$250 million. Also, Italy offered US$95 million, increased later to US$113 million of which US$42 million was donated by the population using the SMS system Four countries, Australia, India, Japan and the United States formed an ad-hoc corroborative group, and it was the origin of Quadrilateral Security Dialogue.

According to USAID, the US has pledged additional funds in long-term U.S. support to help the tsunami victims rebuild their lives. On 9 February 2005, President Bush asked Congress to increase the U.S. commitment to a total of US$950 million. Officials estimated that billions of dollars would be needed. Bush also asked his father, former President George H. W. Bush, and former President Bill Clinton to lead a U.S. effort to provide private aid to the tsunami victims.

In mid-March, the Asian Development Bank reported that over US$4 billion in aid promised by governments was behind schedule. Sri Lanka reported that it had received no foreign government aid, while foreign individuals had been generous. Many charities were given considerable donations from the public. For example, in the United Kingdom, the public donated roughly £330 million sterling (nearly US$600 million). This considerably outweighed the allocation by the government to disaster relief and reconstruction of £75 million and came to an average of about £5.50 (US$10) donated by every citizen.

In August 2006, fifteen local aid staff working on post-tsunami rebuilding were found executed in north-east Sri Lanka after heavy fighting, the main umbrella body for aid agencies in the country said.

Chapter 9

2005 Kashmir Earthquake

The **2005 Kashmir earthquake** occurred at 08:50:39 Pakistan Standard Time on 8 October in Pakistani-administered Azad Kashmir. It was centred near the city of Muzaffarabad, and also affected nearby Balakot in Khyber Pakhtunkhwa and some areas of Indian-administered Jammu and Kashmir. It registered a moment magnitude of 7.6 and had a maximum Mercalli intensity of VIII (*Severe*).

The earthquake also affected countries in the surrounding region where tremors were felt in Afghanistan, Tajikistan, India and China's Xinjiang region. The severity of the damage caused by the earthquake is attributed to severe upthrust. It is considered the deadliest earthquake to hit South Asia, surpassing the 1935 Quetta earthquake.

Earthquake

Kashmir lies in the area of collision of the Eurasian and Indian tectonic plates. The geological activity born out of this collision, also responsible for the birth of the Himalayan mountain range, is the cause of unstable seismicity in the region. The United States Geological Survey (USGS) measured its magnitude as a minimum of 7.6 on the moment magnitude scale, with its epicentre about 19 km (12 mi) northeast of Muzaffarabad, Azad Kashmir, and 100 km (62 mi) north-northeast of the national capital Islamabad.

Damage

Most of the devastation hit north Pakistan and Pakistan administered Kashmir. In Kashmir, the three main districts were badly affected and Muzaffarabad, the state capital of Pakistan-administered Kashmir, was hardest hit in terms of casualties and destruction. Hospitals, schools, and rescue services including police and armed forces were paralysed. There was virtually no infrastructure and communication was badly affected. More than 70% of all casualties were estimated to have occurred in Muzaffarabad. Bagh, the second-most-affected district, accounted for 15% of the total casualties.

The Pakistani government's official death toll as of November 2005 stood at 87,350 although it is estimated that the death toll could reach over 100,000.

Approximately 138,000 were injured and over 3.5 million rendered homeless. According to government figures, 19,000 children died in the earthquake, most of them in widespread collapses of school buildings. The earthquake affected more than 500,000 families. In addition, approximately 250,000 farm animals died due to the collapse of stone barns, and more than 500,000 large animals required immediate shelter from the harsh winter.

As Saturday is a normal school day in the region, most students were at schools when the earthquake struck. Many were buried under collapsed school buildings. Many people were also trapped in their homes and because it was the month of Ramadan, most people were taking a nap after their pre-dawn meal and did not have time to escape. Reports indicate

that entire towns and villages were completely wiped out in northern Pakistan, with other surrounding areas also suffering severe damage.

- "...a second, massive wave of death will happen if we do not step up our efforts now", Kofi Annan said on 20 October with reference to the thousand remote villages in which people are in need of medical attention, food, clean water and shelter and the 120,000 survivors that have not yet been reached."

At least 1,350 people were killed and 6,266 injured in Jammu and Kashmir state in India. The tremors were felt as far away as Delhi and Punjab in northern India. Four fatalities and 14 injured survivors were reported in Afghanistan.

According to Pakistan's Interior Minister Aftab Ahmad Sherpao, Prime Minister Shaukat Aziz "made the appeal to survivors" on 26 October to come down to valleys and cities for relief, because bad weather, mountainous terrain, landslides and blocked roads are making it difficult for relief workers to reach each house and the winter snows are imminent."

In Islamabad, the Margalla Towers, an apartment complex in sector F-10, collapsed and killed many of the residents. Four deaths were reported in Afghanistan, including a young girl who died in Jalalabad, after a wall collapsed on her. The quake was felt in Kabul, but the effects were minimal there.

Aftershocks

There were many secondary earthquakes in the region, mainly to the northwest of the original epicentre. A series of strong

aftershocks occurred near Muzaffarabad. As of 27 October 2005 there had been more than 978 aftershocks with a magnitude of 4.0 and above that continued to occur daily. Since then, measurements from satellites have shown that mountain parts directly above the epicenter have risen by a few meters, giving ample proof that the rising of the Himalayas is still going on, and that this earthquake was a consequence of that.

Response

The **international response to the 2005 Kashmir earthquake** was widespread, as many countries, international organizations and non-governmental organizations offered an abundance of relief aid to the affected regions – particularly Pakistan, which was hit the hardest due to the earthquake's epicentre being around Muzaffarabad, the capital city of Pakistani-administered Azad Jammu and Kashmir. The aid given was in the form of monetary donations and pledges, as well as relief supplies including food, various medical supplies, tents and blankets. Rescue and relief workers as well as peacekeeping troops were sent from different parts of the world to the region, bringing along rescue equipment, including helicopters and rescue dogs. The earthquake displaced some 3.3 million people, while killing around 80,000–100,000.

Africa

- Tunisia - The Tunisian government sent a C-130 plane with 14 tons of relief supplies, including food, blankets and medical supplies to Pakistan.

Asia

- Afghanistan - The Afghan government sent four rescue helicopters from its nascent air force, as well as a fixed-wing plane loaded with four tons of medicine and army medical personnel, to help with disaster relief in the hardest-hit areas of Kashmir. The country also pledged US$500,000 in aid. The Afghan Red Crescent Society has also announced that it will donate 20 tons of dried food and send teams of medical personnel. The aid was given to the local authorities with Pakistan getting most of it because the damages were greater on Pakistani side of the border.
- Cambodia – The Prime Minister of Cambodia, Hun Sen, pledged US$60,000 in assistance.
- People's Republic of China - The government of the People's Republic of China, offered emergency aid worth US$6.2 million to help earthquake victims in Pakistan. A 49-member international rescue team and the first batch of rescue materials were sent to Pakistan on October 9, 2005. US$1 million in cash was sent out on October 10, 2005. Rescue teams with sniffer dogs were deployed throughout the region to search for and rescue any survivors.
- Hong Kong - The government of Hong Kong approved a grant of HK$3.5 million from the Disaster Relief Fund to World Vision Hong Kong in order to undertake relief projects. Hong Kong procured and arranged to air-freight 20 tons of relief supply, including tents and blankets, to Pakistan.

- India - Prime Minister Manmohan Singh offered quake assistance to Pakistan. Indian and Pakistani High Commissioners were in touch regarding cooperation in relief work. India has sent 25 tonnes of relief material to Pakistan including food, blankets and medicine. Indian MNCs companies such as Infosys have offered aid up to $226,000. On October 12, an Ilyushin-76 cargo plane ferried across seven truckloads (about 82 tons) of army medicines, 15,000 blankets and 50 tents and returned to New Delhi. A senior airforce official also stated that they had been asked by the Indian government to be ready to fly out another similar consignment. On October 14, India dispatched the second consignment to relief material to Pakistan, by train through the Wagah Border. The consignment includes 5,000 blankets, 370 tents, 5 tons of plastic sheets and 12 tons of medicine. The third consignment is of medicine and relief material is being readied and will be sent shortly, also by train. India also pledged $25 million as aid to Pakistan.

India opened the first of three points at Chakan Da Bagh, in Poonch, on the Line of Control (LoC) between India and Pakistan for the 2005 Kashmir earthquake relief work. (Rediff)

- Indonesia - Indonesia is sending a C-130 Hercules aircraft with a medical team, medicine and various emergency materials to Pakistan. The Indonesian Red Cross (PMI) is also ready to send humanitarian relief and a special team.

- Iran - Iran dispatched different food items, blankets, tents and medicine through two aircraft.
- Israel - Israel offered aid to Pakistan and India immediately following the earthquake; Pakistan accepted the aid on the condition that the aid be channeled through a third-party organization such as the United Nations. The nature of the aid is unknown.
- Jordan – Prince Rashid bin Al Hassan, chief of the Jordanian Relief Agencies arrived in Pakistan on October 11, bringing with him a 50-bed mobile hospital to be deployed in Rawalakot.
- Japan - Japan has provided experts and equipment for rescue operations. On October 11, Japan pledged a further US$20 million and stated that it was ready to dispatch dozens of troops and several transport helicopters to aid relief efforts. A statement by the Japanese Defense Ministry clarified on October 12, that they would be sending approximately 290 troops and three helicopters to help with the relief work in Pakistan.
- Kuwait - The Kuwaiti government announced a US$100 million in aid to Pakistan. Half of the aid package will be offered in the form of relief assistance, while the other half (approximately $51 million) will be used to repair damaged infrastructure.
- Malaysia - Malaysia has dispatched a search-and-rescue team to quake-ravaged Pakistan and US$1 million (MYR 3.8 million) to its government. The Malaysian team comprises 50 men from various agencies and non-governmental organisations,

including the National Security Division, Special Malaysia Disaster Assistance and Rescue Team (SMART), Kuala Lumpur Hospital, Malaysian Red Crescent Society and Mercy Malaysia.

- Nepal – Nepal has offered US$50,000 in relief to Pakistan.
- Pakistan - In late 2006, a staggering $20 billion development scheme was mooted by Pakistan for reconstruction and rehabilitation of the earthquake hit zones in Azad Kashmir. A land use plan for Muzaffarabad city had been prepared by Japan International Cooperation Agency.
- Qatar - A spokesman for the Qatari foreign ministry said that the country was also willing to give humanitarian assistance to Pakistan.
- Saudi Arabia - Saudi King Abdullah has announced an emergency aid package worth 133 million dollars for Pakistan. Earlier, Saudi King Abdullah ordered the rapid establishment of an airlift of doctors, medicine, tents and emergency supplies to the affected region. The Saudi public has also made a big contribution to helping victims of the earthquake, on the call of Saudi government. The Saudi government went one step further by institutionalizing this assistance in the form of Saudi Public Assistance for Pakistan Earthquake victims (SPAPEV).
- Singapore - Singaporean response to 2005 Kashmir earthquake: Prime Minister Lee Hsien Loong, on behalf of the people of Singapore, expressed his deepest condolences and sympathies to the families of the victims. The Singapore Civil

Defence Force was preparing to dispatch a 44-member Disaster Assistance and Rescue Team to help Pakistan's relief and rescue operations. Another two medical relief teams were also sent.

- South Korea - The South Korean government sent US$500,000 along with blankets, relief food and medical supplies to Pakistan as part of their initial response. A further $3 million in aid was announced by the Ministry of Foreign Affairs and Trade on October 10.
- Turkey - Turkey is sending 30 aircraft carrying medical teams to Pakistan. Furthermore, on October 20 Turkey announced a relief package of US$150 million; financial assistance of $100 million and relief goods worth $50 million including 1 million blankets, 50,000 tonnes of flour and 25,000 tonnes of sugar. The Turkish Red Crescent sent 90 health personnel to Pakistan, built tent cities and hospitals. The Turkish Red Crescent has also started building a new tent city that will provide shelter for 70,000 people.
- United Arab Emirates - The total monetary commitment so far is US$100 million. United Arab Emirates President Khalifa bin Zayed Al Nahyan, has ordered the immediate dispatch of humanitarian aid to the region and rescue teams. The Dubai police have also begun to leave for Pakistan.

Europe

- Norway - Norway provided some NOK 240 million ($38 million) in aid.

- Poland - Poland sent rescue dogs, medics and other disaster specialists
- Belgium - Belgian Federal Government allocates EUR 250,000 (PKR 18 million) and Flemish Government EUR 125,000 (PKR 9 million) for equipment and relief assistance in Pakistan and India. A 5 people strong rescue team has been sent and 22 people of the special B-fast rescue team, departed for the region on October 11, 2005. The main purpose of the B-fast team is to set up a field hospital for performing basic operations.
- Czech Republic - The prime minister Jiří Paroubek announced on TV, that the Czech Republic will provide the victims with CZK 25 million (PKR 61 million).
- Denmark - The Danish Government initially granted DKK 10 million (PKR 97 million) in aid, but has since offered two additional grants of DKK 20 million each, making the total aid DKK 50 million (PKR 485 million).
- Estonia - Estonia sent an 18-member medical disaster relief team to the northern Pakistan city Batagram. The team worked there for two weeks, during which they built up a hospital tent complex, which was the main facility in the city for medical assistance
- Finland - Ministry for Foreign Affairs of Finland will allocate EUR 1 million to support the joint field hospital of Finnish and Norwegian Red Cross organizations.

  The hospital staff includes 20 Finnish medical workers, who will leave for Pakistan on October 12,

2005 and October 13, 2005. Finland also donated 1.000 tents capable of housing 15.000 individuals.

- France - France is continuing its efforts to assist the earthquake victims in Pakistan. After sending many rescue teams with dogs and equipment for rescue operations, French aid to Pakistan was, in November 2005, reaching 10.5 million euros. In addition to this, once must also consider France's contribution to EU programs and the generous contributions to various NGOs and private companies mobilized in France and in the stricken region since the first day of the quake. On the night of the earthquake, French authorities rushed 25 civil security personnel, 20 rescuers accompanied by dogs and specialized search and rescue material, 41 SAMU (France's emergency medical agency) personnel, and 18 military doctors along with relief materials.
- Germany - Germany has sent a team of 16 THW experts with dogs and equipment for locating people in collapsed buildings. The German Red Cross stands by with tents, water-purification equipment and mobile hospitals, to support the work of its partner organizations in the region.
- Netherlands - The Dutch department of International Co-operation promised EUR 1 million. A team of 66 rescue workers has arrived and works now in Bagh. The government added EUR 10 million, on October 11, 2005.
- Russia - Russia sent two flights carrying rescue teams with dogs and equipment for rescue operations, and it also sent a field hospital.

- Sweden - Sweden has given 196 million kronor (24,2 million dollars approximately). Sweden is prepared to assist a rescue effort led by the UN in Pakistan according to Swedish Minister for Foreign Affairs Laila Freivalds.
- Switzerland - Switzerland dispatched ten disaster relief experts to Islamabad and the Swiss government pledged CHF 1 million and non-governmental organisations pledged another CHF 750,000.
- United Kingdom - Foreign Secretary Jack Straw said that Britain was sending out 60 disaster response workers including 50 medical staff. International Development Secretary Hilary Benn announced an initial allocation of PKR 10 million, or about GBP 95,000. As of mid-November 2005, Britain has pledged over GBP 100 million. On October 31, 2005 Virgin Atlantic operated a humanitarian aid charter flight to the capital of Pakistan, Islamabad with 55 tonnes of aid for the affected by the earthquake in Pakistan.

Americas

- Canada - Canada has already offered CAD 100,000 (PKR 5 million) to the International Red Cross and Red Crescent Movement for early needs assessment. An additional CAD 200,000 (PKR 10 million) is being provided to the Canadian High Commission in Pakistan to respond to urgent requirements, i.e. housing, water, food and clothing. The Minister for International Cooperation, Aileen Carroll, has also announced a pledge of CAD 20

million (PKR 1 billion), including 21 tonnes of blankets, dispatched by Canadian Forces aircraft, some of which are being routed to Pakistan from current operations in Afghanistan. The Canadian government also pledged to match all public funds as well as lease two helicopters from the United Nations. A joint team of government officials has also been sent to evaluate further assistance, including the possibility of sending the Disaster Assistance Response Team (DART). Also, due to the fact that many Canadians criticized their government of reacting slowly 10 months ago when the Asian tsunami hit, Canadian Prime Minister Paul Martin has challenged Canada by saying that his government will match whatever donations Canadians make over the next two weeks to NGOs operating in the region. On October 26, 2005, CIDA increased its funding to $57 million, including $10 million donated to the South Asia Earthquake Matching Fund and the other half to the UN and the Red Cross movement.

- Cuba – President Fidel Castro offered, in a letter addressed to the President of Pakistan and made public by officials in Havana, to send 200 doctors to Pakistan in order to help treat the victims of the earthquake. Some 2,260 Cuban health brigadistas, more than 1,400 of them doctors, are in the area of Kashmir. The fully equipped Cuban Field Hospitals will be handed over to the Pakistani government. The Cuban Government has provided 234.5 tons of medicines and disposable materials, and 275.7 tons of most leading-edge equipment. More than 300

students of medicine have taken courses in the Cuban Field Hospitals. The Cuban Government has decided to offer a wide and free medicine scholarships program for 1,000 young Pakistanis from rural communities.
The first Cuban medical team was in Pakistan on October 14, six days after the earthquake, the fast acceptance of the aid was a surprise due to the close relation of Pakistan and the US; the two countries have not even exchanged Ambassadors at that time. The leading Pakistani newspaper *Dawn* quoted President Musharraf as saying that "one of the most heart-warming letters of support" following the earthquake was from Fidel Castro. In his letter, Castro said that it was difficult for him to rest when thousands of Pakistanis were spending their days in pain, awaiting surgery.

- United States - The United States announced that it would provide an initial contribution of US$156 million (PKR 3 billion) for emergency relief in Pakistan, and teams from the United States were the first on the scene to deliver assistance. The U.S. military also provided supplies and assistance. As of November 3, the U.S. Department of Defense (DOD) has 933 personnel providing relief and reconstruction assistance in support of the Pakistan earthquake relief effort. Five CH-47 Chinook and three UH-60 Black Hawk helicopters are being moved into Pakistan immediately, and a C-17 Globemaster III military aircraft has already been assigned to bring blankets, tents and other relief supplies to the victims. The 212th Mobile Army Surgical Hospital

(MASH), established October 25 in Muzaffarabad, currently has 36 Intensive Care Unit beds, 60 intermediate minimal care beds, and two operating rooms. To date the MASH has performed 46 surgeries, and treated 548 non-surgical patients. Furthermore, a 23-member logistical support group is also being dispatched from McGuire Air Force Base in New Jersey. The United States Agency for International Development has provided more than US$41.8 million for relief work in Pakistan, including nine completed airlifts of relief supplies. The airlifts delivered a total of 45,000 blankets, 1,570 winterized tents, 6,150 rolls of plastic sheeting for approximately 30,750 families, 15,000 water containers, 17 water bladders, 2 water purification units, 10 WHO emergency health kits, and 20 concrete cutting saws. USAID has also committed funds to the UN, other international organizations and NGOs. On Wednesday, November 9, 2005, business leaders from GE, UPS, Pfizer, Xerox, and Citigroup met with President Bush at the White House to announce the launch of the South Asia Earthquake Relief Fund and website.

Oceania

- Australia - Parliamentary Secretary for Foreign Affairs Bruce Billson offered condolences and said that Australia was donating A$500,000 (PKR23 million) for medical and relief assistance to help provide medical help and shelter to affected communities. Since then, Foreign Minister Alexander

Downer has said the Government has increased its total aid pledge to A$5.5 million (PKR250 million). As of the 11 October 2005, this has been extended by A$4.5 million (PKR 204 million), bringing its total contribution to A$10 million (PKR 453 million) In a Ministerial Press Release Defence on November 9, Defence Minister Robert Hill announced an ADF deployment of about 140 personnel; comprising a command element, an aviation detachment of four Blackhawk helicopters, and logistics and communication personnel. They are to be based in Islamabad and establish a central medical facility located in Dhanni a region 20 km north-east of Muzaffarabad to support efforts. The deployment will last six months with an estimated cost of A$20 million.

- New Zealand - Caretaker Associate Minister of Foreign Affairs and Trade Marian Hobbs said the government aid agency NZAID would make an initial contribution of NZD 750,000 (PKR 31 million) to the international relief effort. As of the 14 October 2005, this has been extended by NZD 750,000 (PKR 31 million), bringing its total contribution to NZD 1.5 million (PKR 62 million)

Multinational organizations

- United Nations — An eight-member U.N. relief team arrived in Pakistan to aid in search-and-rescue operations, coordinate relief efforts and assess the impact of the quake. Agencies involved include the: United Nations Children's Fund, United Nations

World Food Programme, United Nations Population Fund and the International Nongovernmental Organizations Forum. Supplies such as blankets, clothes, tents, food for infants and medicine were being sent to the disaster regions. The Office for the Coordination of Humanitarian Affairs has released US$100,000 (PKR 5 million) of emergency fund for immediate relief aid.

- World Health Organization - WHO is rushing 100,000 doses of anti-tetanus globulin to Pakistan as part of their relief effort. WHO already has an extensive deployment in Pakistan's affected area.
- European Union — The European Commission released EUR 3.6 million (PKR 260 million) on 9 October. Funds are being made available to partner humanitarian organisations through ECHO, the humanitarian aid department of the European Commission.
- Organisation of the Islamic Conference (OIC) — Secretary general Ekmeleddin Ihsanoglu expressed immense shock and sadness at the tragedy and conveyed his "profound and sincere condolences to the government and the brotherly people of the Islamic Republic of Pakistan". He strongly appealed to all OIC member states and the international community, to expeditiously extend all possible humanitarian assistance and support to the Government and people of Pakistan, to overcome the impact of this tragedy.
- World Bank Group - On October 9, the World Bank committed US$20 million for recovery in Pakistan. This amount was raised to $40 million on October

11. A further $100 million is offered to build "designed houses" in Northern Pakistan and Kashmir area.

Non-governmental organizations

- Human Aid Focus- was the first NGO to start work in Bagh, Azad Kashmir and have won numerous awards for their emergency response. Since the 2005 earthquake, they have been working in the area building shelters, school and on women empowerment projects.
- Humanity First- The first to reach the earthquake zone. Doctors, paramedics and volunteers from UK, Canada, USA and Pakistan opened medical and tent camps which still continue to provide longterm health care and shelter to the victims of the earthquake.
- Direct Relief - Through October 31, 2006, Direct Relief has provided 1.5 million courses of treatment of specifically requested medicines, supplies, and equipment, along with $1.1 million in cash grants to 12 clinics, hospitals, and organizations, to the relief effort, and continues to provide ongoing programmatic support to its partners.
- Oxfam - An emergency assessment and response team was dispatched to the region. A coordinator said that the "initial needs appear to be tents, blankets, medical kits, food aid, water and trauma counseling for those affected."
- The Sarhad Rural Support Programme provided immediate relief efforts at a large scale following

which it was involved in making damage assessments and paying compensation and monitoring the rebuilding of over 62,000 houses under the project named Earthquake Relief and Rehabilitation Project.

- The International Rescue Corps are deploying a specialist Urban Search and Rescue team of 14 volunteers to Pakistan as part of the wider UK response.
- Red Crescent - Emergency assessment and response teams are being deployed in all parts of the affected region. A team of the International Committee of the Red Cross (ICRC) reached Muzaffarabad on October 10. Further teams deployed in Uri and Jammu with the Indian Red Cross Society. The ICRC has set up a website to facilitate the contact between relatives and friends unable to get in touch with each other.
- The Salvation Army - Is mobilizing some truckloads of relief supplies.
- SOS Children's Villages have announced an emergency relief program in Jammu and Kashmir.
- Subh-e-Nau: An Environment and Public Health Concern was the first to initiate an aid and volunteer coordination mechanism. It later studied and put together the SN Disability Reduction and Rehabilitation Strategy that was presented to the international relief community.
- The SN Disability Program then focused on rehabilitation of persons with spinal cord injury, with the help of national and international volunteers, mainly from Canada.

- The Minhaj Welfare Foundation has been active in Pakistan over a decade. At the time of the earthquake they established tent villages with supplies and full medical facilities.
- The Edhi Foundation has been active in Pakistan for two decades. They are providing food, clothes, blankets and medicine to those affected by the disaster.
- The World Islamic Mission Welfare Trust - are sending out phases of doctors to the area, including both General Physicians and Surgeons with tens of thousands of pounds worth of medicine. They are also setting up various dispensaries within affected areas, as well as collaborating with hospitals within the area to take airlifted injured survivors. Rehabilitation will become the main focus after the immediate phase has passed.
- SPO - Provided relief aid and medical goods at the Lady Reading and Khyber Hospitals, in Peshawar. Till date, goods worth 850 000 Rs. have been sent.
- DEMIRA Deutsche Minenraeumer e.V. deployed an emergency team to Balakot district only hours after the earthquake. In cooperation with the Pakistan army DEMIRA set up a medical facility in the valley of Ghanool providing the hard-hit mountain communities with lifesaving triage and air ambulance.
- JEN Japan Emergency NGOs has started to work for the relief operation on 9 October 2005. Expert came from Japan to provide Non Food Items (NFIs) to the affected people in District Bagh. JEN worked in District Bagh until December 2008. JEN constructed

3 permanent structure (earthquake proof)Schools and 3 Shelter schools, each school contains 2 shelters.

Estimate of financial aid

On November 19, 2005 it was estimated that the international community as a whole pledged about US$5.8 billion.

Effects

A 2016 study showed that the Pakistanis affected by the international relief effort show markedly higher trust in Europeans and Americans.

Chapter 10

Pratibha Patil

Pratibha Devisingh Patil (born 19 December 1934) is an Indian politician who served as the 12th President of India from 2007 to 2012. A member of the Indian National Congress, Patil is the only woman to have held the office. She had previously served as the Governor of Rajasthan from 2004 to 2007.

Early life

Pratibha Devisingh Patil is the daughter of Narayan Rao Patil. She was born on 19 December 1934 in the village of Nadgaon, in the Jalgaon district of Maharashtra, India. She was educated initially at R. R. Vidyalaya, Jalgaon, and subsequently was awarded a master's degree in Political Science and Economics by Mooljee Jetha College, Jalgaon (then under Poona University), and then a Bachelor of Law degree by Government Law College, Bombay, affiliated to the University of Bombay (now University of Mumbai). Patil then began to practice law at the Jalgaon District Court, while also taking interest in social issues such as improving the conditions faced by Indian women.

Patil married Devisingh Ransingh Shekhawat on 7 July 1965. The couple has a daughter and a son, Raosaheb Shekhawat, who is also a politician.

Political career

In 1962, at the age of 27, she was elected to the Maharashtra Legislative Assembly for the Jalgaon constituency. Thereafter she won in the Muktainagar (formerly Edlabad) constituency on four consecutive occasions between 1967 and 1985, before becoming a Member of Parliament in the Rajya Sabha between 1985 and 1990. In the 1991 elections for the 10th Lok Sabha, she was elected as a Member of Parliament representing the Amravati constituency. A period of retirement from politics followed later in the decade.

Patil had held various Cabinet portfolios during her period in the Maharashtra Legislative Assembly and she had also held official positions while in both the Rajya Sabha and Lok Sabha. In addition, she had been for some years the president of the Maharashtra Pradesh Congress Committee and also held office as Director of the National Federation of Urban Co-operative Banks and Credit Societies and as a Member of the Governing Council of the National Co-operative Union of India.

On 8 November 2004 she was appointed as the 17th Governor of Rajasthan, the first woman to hold that office

Presidency

Election

Patil was announced as the United Progressive Alliance (UPA) candidate on 14 June 2007. She emerged as a compromise candidate after the left-wing parties of the alliance would not

agree to the nomination of former Home Minister Shivraj Patil or Karan Singh. Patil had been loyal to the INC and the Nehru–Gandhi family for decades and this was considered to be a significant factor in her selection by INC leader Sonia Gandhi, although Patil said that she had no intention of being a "rubber-stamp president".

In the same month that she was selected, as a member of the UPA Patil was accused of shielding her brother, G. N. Patil, in the 2005 Vishram Patil murder case. Vishram Patil had narrowly defeated G. N. Patil in an election to be the President of the District Congress Committee of Jalgaon and in September of that year had been murdered. Vishram Patil's widow eventually accused G. N. Patil of involvement in the crime and claimed that Pratibha Patil had influenced the criminal investigation and that the issue needed to be examined before presidential immunity became active. Her accusations were rejected by the courts in 2009 but in 2015 G. N. Patil was charged. No reference to the alleged involvement of Pratibha Patil was made at this time.

Due to the presidential role being largely a figurehead position, the selection of the candidate is often arranged by consensus among the various political parties and the candidate runs unopposed. Contrary to the normal pattern of events, Patil faced a challenge in the election. The BBC described the situation as "the latest casualty of the country's increasingly partisan politics and [it] highlights what is widely seen as an acute crisis of leadership". It "degenerated into unseemly mudslinging between the ruling party and the opposition". Her challenger was Bhairon Singh Shekhawat, the incumbent vice-president and a Bharatiya Janata Party (BJP) veteran.

Shekhawat stood as an independent candidate and was supported by the National Democratic Alliance (NDA), a group led by the BJP, although the Shiv Sena party, which was a part of NDA, supported her because of her Marathi origin.

Those opposed to Patil becoming president claimed that she lacked charisma, experience, and ability. They also highlighted her time spent away from high-level politics and queried her belief in the supernatural, such as her claim to have received a message from Dada Lekhraj, a dead guru. Various specific issues were raised, such as a comment made by her in 1975 that those suffering from hereditary diseases should be sterilized. Another alleged that while a Member of Parliament for Amravati she diverted Rs 3.6 million from her MPLADS fund to a trust run by her husband.

This was in violation of Government rules which barred MPs from providing funds to organizations run by their relatives. The parliamentary affairs minister denied any wrongdoing on Patil's part, and noted that the funds utilized under MPLADS are audited by the Comptroller and Auditor General of India.

Patil won the election held on 19 July 2007. She garnered nearly two-thirds of the votes and was sworn in as India's first woman president on 25 July 2007.

In office

Patil's term as the President of India saw various controversies and is widely considered as lacklustre. She commuted death sentences of 35 petitioners to life, a record. President's Office, however, defended this by saying that President had granted

clemency to the petitioners after due consideration and examining the advice of the Home Ministry.

Patil was noted for having spent more money on foreign trips, and having taken a greater number of foreign trips, than any previous president. Sometimes accompanied by as many as 11 members of her family, there had been 12 foreign trips spanning 22 countries by May 2012, when she was away on her 13th trip.

Those completed travels had cost Rs 205 crore (Rs 2.05 billion). The Ministry of External Affairs said that taking family members "was not abnormal".

The Office of President has a five-year term and Patil retired from the role in July 2012.

Patil allegedly used public funds to build a retirement mansion on a 260,000 square feet (24,000 m) plot of military land in Pune.Tradition is that a retiring president either takes residence in Government accommodation in Delhi or moves back to their residence in their home state;her use of government money to build a retirement home at the end of the presidential term was unprecedented.

Other controversies that arose after her retirement included her desire to claim both an official government car and fuel allowance for the running of a private car, despite rules clearly stipulating that this was an either/or situation.

She also took possession of many gifts that had been given to her in her official role and was later forced to return them.

Business interests

Patil set up Vidya Bharati Shikshan Prasarak Mandal, an educational institute which runs a chain of schools and colleges in Amravati, Jalgaon, Pune and Mumbai.

She also set up Shram Sadhana Trust, which runs hostels for working women in New Delhi, Mumbai and Pune; and an engineering college for rural students in Jalgaon district. She also co-founded a cooperative sugar factory known as Sant Muktabai Sahakari Sakhar Karkhana at Muktainagar.

In addition, Patil founded a cooperative bank, Pratibha Mahila Sahakari Bank, that ceased trading in February 2003 when its licence was cancelled by the Reserve Bank of India. Among other failings, the bank had given illegal loans to her relatives that exceeded the bank's share capital. It had also given a loan to her sugar mill which was never repaid.

The bank waived these loans, and this drove it into liquidation. The government liquidator of the bank, P. D. Nigam, said, "The fact that relatives of the founder chairperson (Pratibha Patil) were among those indiscriminately granted loans and that some illegal loan waivers were done has come up in our audit." Six of the top ten defaulters in the bank were linked to her relatives.

The INC claimed that Patil had not been involved with the bank since 1994 but *The Indian Express* reported that it had official documents showing her involvement as late as 2002.

Honours

-  : Special Category Sash (*Banda en Categoría Especial*) of the Mexican Order of the Aztec Eagle (awarded 3 August 2018 - presented 1 June 2019,  Mexico

Chapter 11

President George W. Bush Signs into Law a Nuclear Deal with India

George W. Bush

George Walker Bush (born July 6, 1946) is an American politician and businessman who served as the 43rd president of the United States from 2001 to 2009. A member of the Republican Party, Bush previously served as the 46th governor of Texas from 1995 to 2000. He was born into the Bush family; his father, George H. W. Bush, was the 41st president of the United States from 1989 to 1993.

As the eldest son of Barbara and George H. W. Bush, he is the second son of a former United States president to himself become president, with the first being John Quincy Adams, the son of John Adams. He flew warplanes in the Texas and Alabama Air National Guard. After graduating from Yale College in 1968 and Harvard Business School in 1975, he worked in the oil industry. Bush married Laura Welch in 1977 and unsuccessfully ran for the U.S. House of Representatives shortly thereafter.

He later co-owned the Texas Rangers baseball team before defeating incumbent Ann Richards in the 1994 Texas gubernatorial election. As governor, Bush successfully sponsored legislation for tort reform, increased education funding, set higher standards for schools, and reformed the

criminal justice system. Bush also helped make Texas the leading producer of wind powered electricity in the U.S. Bush was elected president in 2000 when he defeated Democratic incumbent Vice President Al Gore after a narrow and contested win that involved a Supreme Court decision to stop a recount in Florida. He became the fourth person to be elected president without a popular vote victory.

Upon taking office, Bush pushed through a $1.3 trillion tax cut program and the No Child Left Behind Act, a major education reform bill. He also pushed for socially conservative efforts, such as the Partial-Birth Abortion Ban Act and faith-based welfare initiatives.

A decisive event reshaping his administration was the terrorist attacks on September 11, 2001, Bush created the United States Department of Homeland Security and declared a global war on terrorism in response. He ordered an invasion of Afghanistan beginning the War in Afghanistan to overthrow the Taliban, destroy the terrorist group al-Qaeda, and capture Osama bin Laden. He also signed the controversial Patriot Act in order to authorize surveillance of suspected terrorists. In 2003, Bush ordered an invasion of Iraq which began the Iraq War, arguing that the Saddam Hussein regime possessed weapons of mass destruction. Intense criticism came when no WMD stockpiles were ever found nor evidence of an operational relationship with al-Qaeda. Bush also signed into law the Medicare Modernization Act, which created Medicare Part D, and funding for the AIDS relief program, PEPFAR.

Bush was re-elected to a second term in 2004, defeating Democratic senator John Kerry. During his second term, Bush

reached multiple free trade agreements and successfully appointed John Roberts and Samuel Alito to the Supreme Court. He sought major changes to Social Security and immigration laws, but both efforts failed in Congress. The wars in Afghanistan and Iraq continued, and in 2007 he launched a surge of troops in Iraq. Bush received criticism from across the political spectrum for his handling of Hurricane Katrina and for the midterm dismissal of U.S. attorneys. In the midst of Bush's unpopularity, the Democratic Party regained control of Congress in the 2006 elections. In December 2007, the U.S. entered the Great Recession, prompting the Bush administration to obtain congressional approval for multiple economic programs intended to preserve the country's financial system, including the Troubled Asset Relief Program (TARP) to buy toxic assets from financial institutions.

Bush was among the most popular, as well as unpopular, U.S. presidents in history; he received the highest recorded approval ratings in the wake of the 9/11 attacks, but one of the lowest such ratings during the 2008 financial crisis. Bush finished his second term in office in 2009 and returned to Texas. In 2010, he published his memoir, *Decision Points*. His presidential library opened in 2013. His presidency has been rated as below-average in historical rankings of U.S. presidents, although public and scholarly favorability of his presidency have improved since leaving office.

Early life and career

George Walker Bush was born on July 6, 1946, at Grace-New Haven Hospital (now Yale New Haven Hospital) in New Haven, Connecticut, while his father was a student at Yale. He was the

first child of George Herbert Walker Bush and Barbara Pierce. He was raised in Midland and Houston, Texas, with four siblings, John, Neil, Marvin and Dorothy. Another younger sister, Robin, died from leukemia at the age of three in 1953. His paternal grandfather, Prescott Bush, was a U.S. Senator from Connecticut. His father was Ronald Reagan's vice president from 1981 to 1989 and the 41st U.S. president from 1989 to 1993. Bush has English and some German ancestry, along with more distant Dutch, Welsh, Irish, French, and Scottish roots.

Education

Bush attended public schools in Midland, Texas until the family moved to Houston after he had completed seventh grade. He then spent two years at The Kinkaid School, a prep school in Piney Point Village, Texas in the Houston area.

Bush attended high school at Phillips Academy, a boarding school in Andover, Massachusetts, where he played baseball and was the head cheerleader during his senior year. He attended Yale University from 1964 to 1968, graduating with a Bachelor of Arts degree in history.

During this time, he was a cheerleader and a member of the Delta Kappa Epsilon, serving as the president of the fraternity during his senior year. Bush became a member of the Skull and Bones society as a senior. Bush was a rugby union player and was on Yale's 1st XV. He characterized himself as an average student. His GPA during his first three years at Yale was 77, and he had a similar average under a nonnumeric rating system in his final year.

In the fall of 1973, Bush entered Harvard Business School. He graduated in 1975 with an MBA degree. He is the only U.S. president to have earned an MBA.

Family and personal life

Bush was engaged to Cathryn Lee Wolfman in 1967, but the engagement did not last. Bush and Wolfman remained on good terms after the end of the relationship. While Bush was at a backyard barbecue in 1977, friends introduced him to Laura Welch, a schoolteacher and librarian. After a three-month courtship, she accepted his marriage proposal and they wed on November 5 of that year. The couple settled in Midland, Texas. Bush left his family's Episcopal Church to join his wife's United Methodist Church. On November 25, 1981, Laura Bush gave birth to fraternal twin daughters, Barbara and Jenna. Bush describes being challenged by Billy Graham to consider faith in Jesus "Christ as the risen Lord", how he began to read the Bible daily, "surrendering" to the "Almighty", that "faith is a walk" and that he was "moved by God's love".

Alcohol abuse

Prior to getting married, Bush struggled with multiple episodes of alcohol abuse. In one instance on September 4, 1976, he was pulled over near his family's summer home in Kennebunkport, Maine, for driving under the influence of alcohol. He was cited for DUI, fined $150 (equivalent to $682 in 2020), and got his Maine driver's license briefly suspended. Bush said his wife has had a stabilizing effect on his life, and he attributes her influence to his 1986 decision to give up alcohol. While Governor of Texas, Bush said of his wife, "I saw

an elegant, beautiful woman who turned out not only to be elegant and beautiful, but very smart and willing to put up with my rough edges, and I must confess has smoothed them off over time." Bush also claims that his faith in God was critical in the process to give up drink. "I believe that God helped open my eyes, which were closing because of booze".

Hobbies

Bush has been an avid reader throughout his adult life, preferring biographies and histories. During his presidency, Bush read the Bible daily, though at the end of his second term he said on television that he is "not a literalist" about Bible interpretation. Walt Harrington, a journalist, recalled seeing "books by John Fowles, F. Scott Fitzgerald, James Joyce, and Gore Vidal lying about, as well as biographies of Willa Cather and Queen Victoria" in his home when Bush was a Texas oilman. Other activities include cigar smoking and golf. After leaving the White House, Bush took up oil painting.

Military career

In May 1968, Bush was commissioned into the Texas Air National Guard. After two years of training in active-duty service, he was assigned to Houston, flying Convair F-102s with the 147th Reconnaissance Wing out of the Ellington Field Joint Reserve Base. Critics, including former Democratic National Committee Chairman Terry McAuliffe, have alleged that Bush was favorably treated due to his father's political standing as a member of the House of Representatives, citing his selection as a pilot despite his low pilot aptitude test scores and his irregular attendance. In June 2005, the United

States Department of Defense released all the records of Bush's Texas Air National Guard service, which remain in its official archives.

In late 1972 and early 1973, he drilled with the 187th Fighter Wing of the Alabama Air National Guard. He had moved to Montgomery, Alabama, to work on the unsuccessful U.S. Senate campaign of Republican Winton M. Blount. In 1972, Bush was suspended from flying for failure to take a scheduled physical exam. He was honorably discharged from the Air Force Reserve on November 21, 1974.

He remains the most recent President to serve in the United States Military.

Business career

In 1977, Bush established Arbusto Energy, a small oil exploration company, although it did not begin operations until the following year. He later changed the name to Bush Exploration. In 1984, his company merged with the larger Spectrum 7, and Bush became chairman. The company was hurt by decreased oil prices, and it folded into HKN, Inc., with Bush becoming a member of HKN's board of directors. Questions of possible insider trading involving HKN arose, but a Securities and Exchange Commission (SEC) investigation concluded that the information Bush had at the time of his stock sale was not sufficient to constitute insider trading.

In April 1989, Bush arranged for a group of investors to purchase a controlling interest in the Texas Rangers baseball franchise for $89 million and invested $500,000 himself to start. He then was managing general partner for five years. He

actively led the team's projects and regularly attended its games, often choosing to sit in the open stands with fans. Bush's sale of his shares in the Rangers in 1998 brought him over $15 million from his initial $800,000 investment.

Early political involvement

In 1978, Bush ran for the House of Representatives from Texas's 19th congressional district. The retiring member, George H. Mahon, had held the district for the Democratic Party since 1935. Bush's opponent, Kent Hance, portrayed him as out of touch with rural Texans, and Bush lost the election with 46.8 percent of the vote to Hance's 53.2 percent.

Bush and his family moved to Washington, D.C., in 1988 to work on his father's campaign for the U.S. presidency. He was a campaign advisor and liaison to the media, and assisted his father by campaigning across the country. In December 1991, Bush was one of seven people named by his father to run his father's 1992 presidential re-election campaign, as a "campaign advisor". The previous month, his father had asked him to tell White House chief of staff John H. Sununu to resign.

Governor of Texas (1995–2000)

- Bush declared his candidacy for the 1994 Texas gubernatorial election at the same time his brother Jeb sought the governorship of Florida. His campaign focused on four themes: welfare reform, tort reform, crime reduction, and education improvement. Bush's campaign advisers were Karen

Hughes, Joe Allbaugh, and Karl Rove.After easily winning the Republican primary, Bush faced popular Democratic incumbent Governor Ann Richards. In the course of the campaign, Bush pledged to sign a bill allowing Texans to obtain permits to carry concealed weapons. Richards had vetoed the bill, but Bush signed it into law after he became governor. According to *The Atlantic*, the race "featured a rumor that she was a lesbian, along with a rare instance of such a tactic's making it into the public record – when a regional chairman of the Bush campaign allowed himself, perhaps inadvertently, to be quoted criticizing Richards for 'appointing avowed homosexual activists' to state jobs". *The Atlantic*, and others, connected the lesbian rumor to Karl Rove, but Rove denied being involved. Bush won the general election with 53.5 percent against Richards' 45.9 percent.

Bush used a budget surplus to push through Texas's largest tax-cut, $2 billion. He extended government funding for organizations providing education of the dangers of alcohol and drug use and abuse, and helping to reduce domestic violence. Critics contended that during his tenure, Texas ranked near the bottom in environmental evaluations. Supporters pointed to his efforts to raise the salaries of teachers and improve educational test scores.

In 1999, Bush signed a law that required electric retailers to buy a certain amount of energy from renewable sources (RPS), which helped Texas eventually become the leading producer of wind powered electricity in the U.S.

In 1998, Bush won re-election with a record 69 percent of the vote. He became the first governor in Texas history to be elected to two consecutive four-year terms. In his second term, Bush promoted faith-based organizations and enjoyed high approval ratings. He proclaimed June 10, 2000, to be Jesus Day in Texas, a day on which he urged all Texans to "answer the call to serve those in need".

Throughout Bush's first term, he was the focus of national attention as a potential future presidential candidate. Following his re-election, speculation soared, and within a year he decided to seek the 2000 Republican presidential nomination.

Presidential campaigns

2000 presidential candidacy

Primary

Incumbent Democratic president Bill Clinton was in his second and final term, and the field for nomination in both parties was wide open. Bush was the governor of Texas in June 1999 when he announced his candidacy for president, joining John McCain, Alan Keyes, Steve Forbes, Gary Bauer, Orrin Hatch, Elizabeth Dole, Dan Quayle, Pat Buchanan, Lamar Alexander, John Kasich, and Bob Smith.

Bush portrayed himself as a compassionate conservative, implying he was more centrist than other Republicans. He campaigned on a platform that included bringing integrity and honor back to the White House, increasing the size of the

military, cutting taxes, improving education, and aiding minorities. By early 2000, the race had centered on Bush and McCain.

Bush won the Iowa caucuses and, although heavily favored to win the New Hampshire primary, trailed McCain by 19 percent and lost. Despite this he regained momentum and effectively became the front runner after the South Carolina primary, which according to *The Boston Globe* made history for his campaign's negativity. *The New York Times* described it as a smear campaign.

General election

On July 25, 2000, Bush surprised some observers when he selected Dick Cheney – a former White House chief of staff, representative and secretary of defense – to be his running mate. At the time, Cheney was serving as head of Bush's vice presidential search committee. Soon after at the 2000 Republican National Convention, Bush and Cheney were officially nominated by the Republican Party.

Bush continued to campaign across the country and touted his record as Governor of Texas. During his campaign, Bush criticized his Democratic opponent, incumbent Vice President Al Gore, over gun control and taxation.

When the election returns were tallied on November 7, Bush had won 29 states, including Florida. The closeness of the Florida outcome led to a recount. The initial recount also went to Bush, but the outcome was tied up in lower courts for a month until eventually reaching the U.S. Supreme Court. On

December 9, in the controversial *Bush v. Gore* ruling, the Court reversed a Florida Supreme Court decision that had ordered a third count, and stopped an ordered statewide hand recount based on the argument that the use of different standards among Florida's counties violated the Equal Protection Clause of the Fourteenth Amendment.

The machine recount showed that Bush had won the Florida vote by a margin of 537 votes out of six million casts. Although he had received 543,895 fewer individual nationwide votes than Gore, Bush won the election, receiving 271 electoral votes to Gore's 266 (Gore had actually been awarded 267 votes by the states pledged to him plus the District of Columbia, but one D.C. elector abstained). Bush was the first person to win an American presidential election with fewer popular votes than another candidate since Benjamin Harrison in 1888.

2004 presidential candidacy

In his 2004 bid for re-election, Bush commanded broad support in the Republican Party and did not encounter a primary challenge. He appointed Ken Mehlman as campaign manager, and Karl Rove devised a political strategy. Bush and the Republican platform emphasized a strong commitment to the wars in Iraq and Afghanistan, support for the USA PATRIOT Act, a renewed shift in policy for constitutional amendments banning abortion and same-sex marriage, reforming Social Security to create private investment accounts, creation of an ownership society, and opposing mandatory carbon emissions controls. Bush also called for the implementation of a guest worker program for immigrants, which was criticized by conservatives.

The Bush campaign advertised across the U.S. against Democratic candidates, including Bush's emerging opponent, Massachusetts Senator John Kerry. Kerry and other Democrats attacked Bush on the Iraq War, and accused him of failing to stimulate the economy and job growth. The Bush campaign portrayed Kerry as a staunch liberal who would raise taxes and increase the size of government. The Bush campaign continuously criticized Kerry's seemingly contradictory statements on the war in Iraq, and argued that Kerry lacked the decisiveness and vision necessary for success in the War on Terror.

Following the resignation of CIA director George Tenet in 2004, Bush nominated Porter Goss to head the agency. The White House ordered Goss to purge agency officers who were disloyal to the administration. After Goss' appointment, many of the CIA's senior agents were fired or quit. The CIA has been accused of deliberately leaking classified information to undermine the 2004 election.

In the election, Bush carried 31 of 50 states, receiving 286 electoral votes. He won an absolute majority of the popular vote (50.7 percent to his opponent's 48.3 percent). Bush's father George H.W. Bush was the previous president who won an absolute majority of the popular vote; he accomplished that feat in the 1988 election.

Additionally, it was the first time since Herbert Hoover's election in 1928 that a Republican president was elected alongside re-elected Republican majorities in both Houses of Congress.

Presidency (2001–2009)

- Bush had originally outlined an ambitious domestic agenda, but his priorities were significantly altered following the September 11 attacks. Wars were waged in Afghanistan and Iraq, and there were significant domestic debates regarding immigration, healthcare, Social Security, economic policy, and treatment of terrorist detainees. Over an eight-year period, Bush's once-high approval ratings steadily declined, while his disapproval numbers increased significantly. In 2007, the United States entered the longest post-World War II recession.

Economic policy

Bush took office during a period of economic recession in the wake of the bursting of the dot-com bubble. The terrorist attacks also impacted the economy.

His administration increased federal government spending from $1.789 trillion to $2.983 trillion (60 percent), while revenues increased from $2.025 trillion to $2.524 trillion (from 2000 to 2008). Individual income tax revenues increased by 14 percent, corporate tax revenues by 50 percent, and customs and duties by 40 percent.

Discretionary defense spending was increased by 107 percent, discretionary domestic spending by 62 percent, Medicare spending by 131 percent, social security by 51 percent, and income security spending by 130 percent. Cyclically adjusted, revenues rose by 35 percent and spending by 65 percent. The

increase in spending was more than under any predecessor since Lyndon B. Johnson. The number of economic regulation governmental workers increased by 91,196.

The surplus in fiscal year 2000 was $237 billion – the third consecutive surplus and the largest surplus ever. In 2001, Bush's budget estimated that there would be a $5.6 trillion surplus over the next ten years. Facing congressional opposition, Bush held townhall style meetings across the U.S. in order to increase public support for his plan for a $1.35 trillion tax cut program, one of the largest tax cuts in U.S. history. Bush argued that unspent government funds should be returned to taxpayers, saying "the surplus is not the government's money.

The surplus is the people's money." Federal Reserve chairman Alan Greenspan warned of a recession and Bush stated that a tax cut would stimulate the economy and create jobs. Treasury Secretary Paul H. O'Neill, opposed some of the tax cuts on the basis that they would contribute to budget deficits and undermine Social Security.

O'Neill disputes the claim, made in Bush's book *Decision Points*, that he never openly disagreed with him on planned tax cuts. By 2003, the economy showed signs of improvement, though job growth remained stagnant. Another tax cut was passed that year.

Between 2001 and 2008, GDP grew at an average annual rate of 2.125 percent, less than for past business cycles. Bush entered office with the Dow Jones Industrial Average at 10,587, and the average peaked in October 2007 at over 14,000. When Bush left office, the average was at 7,949, one of

the lowest levels of his presidency. Only four other U.S. presidents have left office with the stock market lower than when they began.

Unemployment originally rose from 4.2 percent in January 2001 to 6.3 percent in June 2003, but subsequently dropped to 4.5 percent in July 2007. Adjusted for inflation, median household income dropped by $1,175 between 2000 and 2007, while Professor Ken Homa of Georgetown University has noted that "Median real after-tax household income went up two percent". The poverty rate increased from 11.3 percent in 2000 to 12.3 percent in 2006 after peaking at 12.7 percent in 2004. By October 2008, due to increases in spending, the national debt had risen to $11.3 trillion, more than doubling it since 2000. Most debt was accumulated as a result of what became known as the "Bush tax cuts" and increased national security spending. In March 2006, then-Senator Barack Obama said when he voted against raising the debt ceiling: "The fact that we are here today to debate raising America's debt limit is a sign of leadership failure." By the end of Bush's presidency, unemployment climbed to 7.2 percent.

In December 2007, the United States entered the longest post–World War II recession, caused by a housing market correction, a subprime mortgage crisis, soaring oil prices, and other factors. In February 2008, 63,000 jobs were lost, a five-year record, and in November, over 500,000 jobs were lost, which marked the largest loss of jobs in the United States in 34 years. The Bureau of Labor Statistics reported that in the last four months of 2008, 1.9 million jobs were lost. By the end of 2008, the U.S. had lost 2.6 million jobs.

To aid with the situation, Bush signed a $170 billion economic stimulus package which was intended to improve the economic situation by sending tax rebate checks to many Americans and providing tax breaks for struggling businesses. The Bush administration pushed for significantly increased regulation of Fannie Mae and Freddie Mac in 2003, and after two years, the regulations passed the House but died in the Senate. Many Republican senators, as well as influential members of the Bush Administration, feared that the agency created by these regulations would merely be mimicking the private sector's risky practices. In September 2008, the crisis became much more serious beginning with the government takeover of Fannie Mae and Freddie Mac followed by the collapse of Lehman Brothers and a federal bailout of American International Group for $85 billion.

Many economists and world governments determined that the situation had become the worst financial crisis since the Great Depression. Additional regulation over the housing market would have been beneficial, according to former Federal Reserve chairman Alan Greenspan. Bush, meanwhile, proposed a financial rescue plan to buy back a large portion of the U.S. mortgage market.

Vince Reinhardt, a former Federal Reserve economist now at the American Enterprise Institute, said "it would have helped for the Bush administration to empower the folks at Treasury and the Federal Reserve and the comptroller of the currency and the FDIC to look at these issues more closely", and additionally, that it would have helped "for Congress to have held hearings".

Education and public health

Bush undertook many educational agendas, such as increasing the funding for the National Science Foundation and National Institutes of Health in his first years of office and creating education programs to strengthen the grounding in science and mathematics for American high school students. Funding for the NIH was cut in 2006, the first such cut in 36 years, due to rising inflation.

One of the administration's early major initiatives was the No Child Left Behind Act, which aimed to measure and close the gap between rich and poor student performance, provide options to parents with students in low-performing schools, and target more federal funding to low-income schools. This landmark education initiative passed with broad bipartisan support, including that of Senator Ted Kennedy of Massachusetts. It was signed into law by Bush in early 2002. Many contend that the initiative has been successful, as cited by the fact that students in the U.S. have performed significantly better on state reading and math tests since Bush signed "No Child Left Behind" into law. Critics argue that it is underfunded and that NCLBA's focus on "high-stakes testing" and quantitative outcomes is counterproductive.

On November 1, 2005, Bush announced a *National Strategy for Pandemic Influenza* to prepare the United States for a flu pandemic, which culminated in an implementation plan published by the Homeland Security Council in May 2006.

After being re-elected, Bush signed into law a Medicare drug benefit program that, according to Jan Crawford, resulted in

"the greatest expansion in America's welfare state in forty years" – the bill's costs approached $7 trillion. In 2007, Bush opposed and vetoed State Children's Health Insurance Program (SCHIP) legislation, which was added by the Democrats onto a war funding bill and passed by Congress. The SCHIP legislation would have significantly expanded federally funded health care benefits and plans to children of some low-income families. It was to be funded by an increase in the cigarette tax. Bush viewed the legislation as a move toward socialized health care, and asserted that the program could benefit families making as much as $83,000 per year who did not need the help.

On May 21, 2008, Bush signed into law the Genetic Information Nondiscrimination Act (GINA). The bill aimed to protect Americans against health insurance and employment discrimination based on a person's genetic information. The issue had been debated for 13 years before it finally became law. The measure is designed to protect citizens without hindering genetic research.

Social services and Social Security

Following Republican efforts to pass the Medicare Act of 2003, Bush signed the bill, which included major changes to the Medicare program by providing beneficiaries with some assistance in paying for prescription drugs, while relying on private insurance for the delivery of benefits. The retired persons lobby group AARP worked with the Bush Administration on the program and gave their endorsement. Bush said the law, estimated to cost $400 billion over the first ten years, would give the elderly "better choices and more control over their health care".

Bush began his second term by outlining a major initiative to "reform" Social Security, which was facing record deficit projections beginning in 2005. Bush made it the centerpiece of his domestic agenda despite opposition from some in the U.S. Congress. In his 2005 State of the Union Address, Bush discussed the potential impending bankruptcy of the program and outlined his new program, which included partial privatization of the system, personal Social Security accounts, and options to permit Americans to divert a portion of their Social Security tax (FICA) into secured investments. Democrats opposed the proposal to partially privatize the system.

Bush embarked on a 60-day national tour, campaigning for his initiative in media events known as "Conversations on Social Security" in an attempt to gain public support. Nevertheless, public support for the proposal declined, and the House Republican leadership decided not to put Social Security reform on the priority list for the remainder of their 2005 legislative agenda. The proposal's legislative prospects were further diminished by autumn 2005 due to political fallout from the response to Hurricane Katrina. After the Democrats gained control of both houses of Congress in the 2006 midterm elections, there was no prospect of further congressional action on the Bush proposal for the remainder of his term in office.

Environmental policies

Upon taking office in 2001, Bush stated his opposition to the Kyoto Protocol, an amendment to the United Nations Framework Convention on Climate Change which seeks to impose mandatory targets for reducing greenhouse gas emissions, citing that the treaty exempted 80 percent of the

world's population and would have cost tens of billions of dollars per year. He also cited that the Senate had voted 95–0 in 1997 on a resolution expressing its disapproval of the protocol.

In May 2001, Bush signed an executive order to create an interagency task force to streamline energy projects, and later signed two other executive orders to tackle environmental issues.

In 2002, Bush announced the Clear Skies Act of 2003, which aimed at amending the Clean Air Act to reduce air pollution through the use of emissions trading programs.

Many experts argued that this legislation would have weakened the original legislation by allowing higher emission rates of pollutants than were previously legal. The initiative was introduced to Congress, but failed to make it out of committee.

Later in 2006, Bush declared the Northwestern Hawaiian Islands a national monument, creating the largest marine reserve to date. The Papahānaumokuākea Marine National Monument comprises 84 million acres (340,000 km) and is home to 7,000 species of fish, birds, and other marine animals, many of which are specific to only those islands. The move was hailed by conservationists for "its foresight and leadership in protecting this incredible area".

Bush has said he believes that global warming is real and has noted that it is a serious problem, but he asserted there is a "debate over whether it's man-made or naturally caused". The Bush Administration's stance on global warming remained controversial in the scientific and environmental communities.

Critics have alleged that the administration misinformed the public and did not do enough to reduce carbon emissions and deter global warming.

Energy policies

In his 2006 State of the Union Address, Bush declared, "America is addicted to oil" and announced his Advanced Energy Initiative to increase energy development research.

In his 2007 State of the Union Address, Bush renewed his pledge to work toward diminished reliance on foreign oil by reducing fossil fuel consumption and increasing alternative fuel production. Amid high gasoline prices in 2008, Bush lifted a ban on offshore drilling. However, the move was largely symbolic because there was still a federal law banning offshore drilling. Bush said, "This means that the only thing standing between the American people and these vast oil reserves is action from the U.S. Congress." Bush had said in June 2008, "In the long run, the solution is to reduce demand for oil by promoting alternative energy technologies. My administration has worked with Congress to invest in gas-saving technologies like advanced batteries and hydrogen fuel cells ... In the short run, the American economy will continue to rely largely on oil. And that means we need to increase supply, especially here at home. So my administration has repeatedly called on Congress to expand domestic oil production."

In his 2008 State of the Union Address, Bush announced that the U.S. would commit $2 billion over the next three years to a new international fund to promote clean energy technologies and fight climate change, saying, "Along with contributions

from other countries, this fund will increase and accelerate the deployment of all forms of cleaner, more efficient technologies in developing nations like India and China, and help leverage substantial private-sector capital by making clean energy projects more financially attractive." He also announced plans to reaffirm the United States' commitment to work with major economies, and, through the UN, to complete an international agreement that will slow, stop, and eventually reverse the growth of greenhouse gases; he stated, "This agreement will be effective only if it includes commitments by every major economy and gives none a free ride."

Stem cell research and first veto

Federal funding for medical research involving the creation or destruction of human embryos through the Department of Health and Human Services and the National Institutes of Health has been forbidden by law since the passage of the Dickey-Wicker Amendment in 1995. Bush has said he supports adult stem cell research and has supported federal legislation that finances adult stem cell research. However, Bush did not support embryonic stem cell research. On August 9, 2001, Bush signed an executive order lifting the ban on federal funding for the 71 existing "lines" of stem cells, but the ability of these existing lines to provide an adequate medium for testing has been questioned. Testing can be done on only 12 of the original lines, and all approved lines have been cultured in contact with mouse cells, which creates safety issues that complicate development and approval of therapies from these lines. On July 19, 2006, Bush used his veto power for the first time in his presidency to veto the Stem Cell Research Enhancement Act. The bill would have repealed the Dickey-

Wicker Amendment, thereby permitting federal money to be used for research where stem cells are derived from the destruction of an embryo.

Immigration

Nearly eight million immigrants came to the United States from 2000 to 2005, more than in any other five-year period in the nation's history. Almost half entered illegally. In 2006, Bush urged Congress to allow more than twelve million illegal immigrants to work in the United States with the creation of a "temporary guest-worker program". Bush also urged Congress to provide additional funds for border security and committed to deploying 6,000 National Guard troops to the Mexico–United States border.

From May to June 2007, Bush strongly supported the Comprehensive Immigration Reform Act of 2007, which was written by a bipartisan group of Senators with the active participation of the Bush administration. The bill envisioned a legalization program for illegal immigrants, with an eventual path to citizenship; establishing a guest worker program; a series of border and work site enforcement measures; a reform of the green card application process and the introduction of a point-based "merit" system for green cards; elimination of "chain migration" and of the Diversity Immigrant Visa; and other measures. Bush argued that the lack of legal status denies the protections of U.S. laws to millions of people who face dangers of poverty and exploitation, and penalizes employers despite a demand for immigrant labor. Bush contended that the proposed bill did not amount to amnesty.

A heated public debate followed, which resulted in a substantial rift within the Republican Party, most conservatives opposed it because of its legalization or amnesty provisions. The bill was eventually defeated in the Senate on June 28, 2007, when a cloture motion failed on a 46–53 vote. Bush expressed disappointment upon the defeat of one of his signature domestic initiatives. The Bush administration later proposed a series of immigration enforcement measures that do not require a change in law.

On September 19, 2010, former Israeli Prime Minister Ehud Olmert said that Bush offered to accept 100,000 Palestinian refugees as American citizens if a permanent settlement had been reached between Israel and the Palestinian Authority.

Hurricane Katrina

Hurricane Katrina struck early in Bush's second term and was one of the most damaging natural disasters in U.S. history. Katrina formed in late August during the 2005 Atlantic hurricane season and devastated much of the north-central Gulf Coast of the United States, particularly New Orleans.

Bush declared a state of emergency in Louisiana on August 27 and in Mississippi and Alabama the following day. The eye of the hurricane made landfall on August 29, and New Orleans began to flood due to levee breaches; later that day, Bush declared a major disaster in Louisiana, officially authorizing FEMA to start using federal funds to assist in the recovery effort.

On August 30, DHS Secretary Michael Chertoff declared it "an incident of national significance", triggering the first use of the

newly created National Response Plan. Three days later, on September 2, National Guard troops first entered the city of New Orleans. The same day, Bush toured parts of Louisiana, Mississippi, and Alabama and declared that the success of the recovery effort up to that point was "not enough".

As the disaster in New Orleans intensified, Bush was widely criticized for downplaying his administration's role in the inadequate response. Leaders attacked Bush for having appointed incompetent leaders to positions of power at FEMA, notably Michael D. Brown; federal response resources to respond were also limited as a result of being allocated to the Iraq War and Bush himself did not act upon warnings of floods. Bush responded to mounting criticism by claiming to accept full responsibility for the federal government's failures in its handling of the emergency. It has been argued that with Katrina, Bush passed a political tipping point from which he would not recover.

Midterm dismissal of U.S. attorneys

During Bush's second term, a controversy arose over the Justice Department's midterm dismissal of seven United States Attorneys. The White House maintained that they were fired for poor performance. Attorney General Alberto Gonzales later resigned over the issue, along with other senior members of the Justice Department.

The House Judiciary Committee issued subpoenas for advisers Harriet Miers and Josh Bolten to testify regarding this matter, but Bush directed Miers and Bolten to not comply with those subpoenas, invoking his right of executive privilege. Bush

maintained that all his advisers were protected under a broad executive privilege protection to receive candid advice. The Justice Department determined that the President's order was legal.

Although Congressional investigations focused on whether the Justice Department and the White House were using the U.S. Attorney positions for political advantage, no official findings have been released. On March 10, 2008, the Congress filed a federal lawsuit to enforce their issued subpoenas. On July 31, 2008, a United States district court judge ruled that Bush's top advisers were not immune from Congressional subpoenas.

In all, twelve Justice Department officials resigned rather than testify under oath before Congress. They included Attorney General Alberto Gonzales and his chief of staff Kyle Sampson, Gonzales' liaison to the White House Monica Goodling, aide to the president Karl Rove and his senior aide Sara Taylor. In addition, legal counsel to the president Harriet Miers and deputy chief of staff to the president Joshua Bolten were both found in contempt of Congress.

In 2010, the Justice Department investigator concluded that though political considerations did play a part in as many as four of the attorney firings, the firings were "inappropriately political", but not criminal. According to the prosecutors, there was insufficient evidence to pursue prosecution for any criminal offense.

Foreign policy

During his presidential campaign, Bush's foreign policy platform included support for stronger economic and political

relationship with Latin America, especially Mexico, and a reduction of involvement in "nation-building" and other small-scale military engagements. The administration pursued a national missile defense. Bush was an advocate of China's entry into the World Trade Organization.

After the September 11 attacks, Bush launched the War on Terror, in which the United States military and a small international coalition invaded Afghanistan. In his 2002 State of the Union Address, Bush referred to an "axis of evil" consisting of Iraq, Iran and North Korea. In 2003, Bush then launched the invasion of Iraq, searching for weapons of mass destruction, which he described as being part of the War on Terrorism. Those invasions led to the toppling of the Taliban regime in Afghanistan and the removal of Saddam Hussein from power in Iraq.

Bush began his second term with an emphasis on improving strained relations with European nations. He appointed long-time adviser Karen Hughes to oversee a global public relations campaign. Bush lauded the pro-democracy struggles in Georgia and Ukraine.

In March 2006, Bush reversed decades of U.S. policy when he visited India in a trip focused particularly on areas of nuclear energy, counter-terrorism co-operation; and discussions that would eventually lead to the India–United States Civil Nuclear Agreement. This was in stark contrast to the stance taken by his predecessor, Bill Clinton, whose approach and response to India after the 1998 nuclear tests has been characterized as "sanctions and hectoring".

Midway through Bush's second term, questions arose whether Bush was retreating from his freedom and democracy agenda, which was highlighted in policy changes toward some oil-rich former Soviet republics in central Asia.

In an address before both Houses of Congress on September 20, 2001, Bush thanked the nations of the world for their support following the September 11 attacks. He specifically thanked UK Prime Minister Tony Blair for traveling to Washington to show "unity of purpose with America", and said "America has no truer friend than Great Britain."

September 11 attacks

- The September 11 terrorist attacks were a major turning point in Bush's presidency. That evening, he addressed the nation from the Oval Office, promising a strong response to the attacks. He also emphasized the need for the nation to come together and comfort the families of the victims. Three days after the attacks, Bush visited Ground Zero and met with Mayor Rudy Giuliani, firefighters, police officers, and volunteers. Bush addressed the gathering via a megaphone while standing on rubble: "I can hear you. The rest of the world hears you. And the people who knocked these buildings down will hear all of us soon."

In a September 20 speech, Bush condemned Osama bin Laden and his organization Al-Qaeda, and issued an ultimatum to the Taliban regime in Afghanistan, where bin Laden was operating, to "hand over the terrorists, or ... share in their fate".

War on Terrorism

After September 11, Bush announced a global War on Terror. The Afghan Taliban regime was not forthcoming with Osama bin Laden, so Bush ordered the invasion of Afghanistan to overthrow the Taliban regime. In his January 29, 2002 State of the Union Address, he asserted that an "axis of evil" consisting of North Korea, Iran, and Iraq was "arming to threaten the peace of the world" and "pose[d] a grave and growing danger". The Bush Administration asserted both a right and the intention to wage preemptive war, or preventive war. This became the basis for the Bush Doctrine which weakened the unprecedented levels of international and domestic support for the United States which had followed the September 11 attacks.

Dissent and criticism of Bush's leadership in the War on Terror increased as the war in Iraq continued. In 2006, a National Intelligence Estimate concluded that the Iraq War had become the "cause célèbre for jihadists".

Afghanistan invasion

On October 7, 2001, U.S. and British forces initiated bombing campaigns that led to the arrival of Northern Alliance troops in Kabul on November 13. The main goals of the war were to defeat the Taliban, drive al-Qaeda out of Afghanistan, and capture key al-Qaeda leaders. In December 2001, the Pentagon reported that the Taliban had been defeated, but cautioned that the war would go on to continue weakening Taliban and al-Qaeda leaders. Later that month the UN had installed the Afghan Transitional Administration chaired by Hamid Karzai.

Efforts to kill or capture al-Qaeda leader Osama bin Laden failed as he escaped a battle in December 2001 in the mountainous region of Tora Bora, which the Bush Administration later acknowledged to have resulted from a failure to commit enough U.S. ground troops. It was not until May 2011, two years after Bush left office, that bin Laden was killed by U.S. forces under the Obama administration. Bin Laden's successor, Ayman al-Zawahiri, remains at large.

Despite the initial success in driving the Taliban from power in Kabul, by early 2003 the Taliban was regrouping, amassing new funds and recruits. The 2005 failure of Operation Red Wings showed that the Taliban had returned. In 2006, the Taliban insurgency appeared larger, fiercer and better organized than expected, with large-scale allied offensives such as Operation Mountain Thrust attaining limited success. As a result, Bush commissioned 3,500 additional troops to the country in March 2007.

Iraq invasion

Beginning with his January 29, 2002 State of the Union address, Bush began publicly focusing attention on Iraq, which he labeled as part of an "axis of evil" allied with terrorists and posing "a grave and growing danger" to U.S. interests through possession of weapons of mass destruction.

In the latter half of 2002, CIA reports contained assertions of Saddam Hussein's intent of reconstituting nuclear weapons programs, not properly accounting for Iraqi biological and chemical weapons, and that some Iraqi missiles had a range greater than allowed by the UN sanctions. Contentions that the

Bush Administration manipulated or exaggerated the threat and evidence of Iraq's weapons of mass destruction capabilities would eventually become a major point of criticism for the president.

In late 2002 and early 2003, Bush urged the United Nations to enforce Iraqi disarmament mandates, precipitating a diplomatic crisis. In November 2002, Hans Blix and Mohamed ElBaradei led UN weapons inspectors in Iraq, but were advised by the U.S. to depart the country four days prior to the U.S. invasion, despite their requests for more time to complete their tasks. The U.S. initially sought a UN Security Council resolution authorizing the use of military force but dropped the bid for UN approval due to vigorous opposition from several countries. The Bush administration's claim that the Iraq War was part of the War on Terror had been questioned and contested by political analysts.

- More than 20 nations (most notably the United Kingdom), designated the "coalition of the willing" joined the United States in invading Iraq. They launched the invasion on March 20, 2003. The Iraqi military was quickly defeated. The capital, Baghdad, fell on April 9, 2003. On May 1, Bush declared the end of major combat operations in Iraq. The initial success of U.S. operations increased his popularity, but the U.S. and allied forces faced a growing insurgency led by sectarian groups; Bush's "Mission Accomplished" speech was later criticized as premature. From 2004 until 2007, the situation in Iraq deteriorated further, with some observers arguing that there was a full-scale civil war in Iraq.

> Bush's policies met with criticism, including demands domestically to set a timetable to withdraw troops from Iraq. The 2006 report of the bipartisan Iraq Study Group, led by James Baker, concluded that the situation in Iraq was "grave and deteriorating". While Bush admitted there were strategic mistakes made in regards to the stability of Iraq, he maintained he would not change the overall Iraq strategy. According to Iraq Body Count, some 251,000 Iraqis have been killed in the civil war following the U.S.-led invasion, including at least 163,841 civilians.

In January 2005, elections recognized by the West as free and fair were held in Iraq for the first time in 50 years. This led to the election of Jalal Talabani as president and Nouri al-Maliki as Prime Minister of Iraq. A referendum to approve a constitution in Iraq was held in October 2005, supported by most Shiites and many Kurds.

On January 10, 2007, Bush announced a surge of 21,500 more troops for Iraq, as well as a job program for Iraqis, more reconstruction proposals, and $1.2 billion (equivalent to $1.5 billion in 2020) for these programs. On May 1, 2007, Bush used his second-ever veto to reject a bill setting a deadline for the withdrawal of U.S. troops, saying the debate over the conflict was "understandable" but insisting that a continued U.S. presence there was crucial.

In March 2008, Bush praised the Iraqi government's "bold decision" to launch the Battle of Basra against the Mahdi Army, calling it "a defining moment in the history of a free

Iraq". He said he would carefully weigh recommendations from his commanding General David Petraeus and Ambassador Ryan Crocker about how to proceed after the end of the military buildup in the summer of 2008. He also praised the Iraqis' legislative achievements, including a pension law, a revised de-Baathification law, a new budget, an amnesty law, and a provincial powers measure that, he said, set the stage for the Iraqi elections. By July 2008, American troop deaths had reached their lowest number since the war began, and due to increased stability in Iraq, Bush announced the withdrawal of additional American forces. During his last visit to Iraq in December 2008, Iraqi journalist Muntadhar al-Zaidi threw both of his shoes to Bush amid an official press conference with Iraqi Prime Minister Nouri al-Maliki. Al-Zaidi yelled the strikes on Bush as "farewell kiss" and "for the widows and orphans and all those killed in Iraq."

In March 2010, Center for Public Integrity released a report that President Bush's administration had made more than 900 false pretenses in a two-year period about alleged threat of Iraq against the United States, as his rationale to engage war in Iraq. Senior war crimes prosecutor Benjamin B. Ferencz has suggested that Bush should be tried in the International Criminal Court for '269 war crime charges' related to the Iraq War.

Surveillance

Following the terrorist attacks of September 11, Bush issued an executive order that authorized the President's Surveillance Program. The new directive allowed the National Security Agency to monitor communications between suspected

terrorists outside the U.S. and parties within the U.S. without obtaining a warrant, which previously had been required by the Foreign Intelligence Surveillance Act. As of 2009, the other provisions of the program remained highly classified. Once the Department of Justice Office of Legal Counsel questioned its original legal opinion that FISA did not apply in a time of war, the program was subsequently re-authorized by the President on the basis that the warrant requirements of FISA were implicitly superseded by the subsequent passage of the Authorization for Use of Military Force Against Terrorists.

The program proved to be controversial; critics of the administration and organizations such as the American Bar Association argued that it was illegal. In August 2006, a U.S. district court judge ruled that the NSA electronic surveillance program was unconstitutional, but on July 6, 2007, that ruling was vacated by the United States Court of Appeals for the Sixth Circuit on the grounds that the plaintiffs lacked standing. On January 17, 2007, Attorney General Alberto Gonzales informed U.S. Senate leaders that the program would not be reauthorized by the President, but would be subjected to judicial oversight. Later in 2007, the NSA launched a replacement for the program, referred to as PRISM, which was subject to the oversight of the United States Foreign Intelligence Surveillance Court. This program was not publicly revealed until reports by *The Washington Post* and *The Guardian* emerged in June 2013.

Interrogation policies

Bush authorized the CIA to use waterboarding and several other "enhanced interrogation techniques" that several critics,

including Barack Obama, would label as torture. Between 2002 and 2003, the CIA considered certain enhanced interrogation techniques, such as waterboarding, to be legal based on secret Justice Department legal opinions arguing that terror detainees were not protected by the Geneva Conventions' ban on torture, which was described as "an unconstitutional infringement of the President's authority to conduct war". The CIA had exercised the technique on certain key terrorist suspects under authority given to it in the Bybee Memo from the Attorney General, though that memo was later withdrawn. While not permitted by the U.S. Army Field Manuals which assert "that harsh interrogation tactics elicit unreliable information", the Bush administration believed these enhanced interrogations "provided critical information" to preserve American lives. Critics, such as former CIA officer Bob Baer, have stated that information was suspect, "you can get anyone to confess to anything if the torture's bad enough."

On October 17, 2006, Bush signed the Military Commissions Act of 2006 into law. The new rule was enacted in the wake of the Supreme Court's decision in *Hamdan v. Rumsfeld*, 548 U.S. 557 (2006), which allowed the U.S. government to prosecute unlawful enemy combatants by military commission rather than a standard trial. The law also denied the detainees access to *habeas corpus* and barred the torture of prisoners. The provision of the law allowed the president to determine what constitutes "torture".

On March 8, 2008, Bush vetoed H.R. 2082, a bill that would have expanded congressional oversight over the intelligence community and banned the use of waterboarding as well as other forms of interrogation not permitted under the United

States Army Field Manual on Human Intelligence Collector Operations, saying that "the bill Congress sent me would take away one of the most valuable tools in the War on Terror". In April 2009, the ACLU sued and won release of the secret memos that had authorized the Bush administration's interrogation tactics. One memo detailed specific interrogation tactics including a footnote that described waterboarding as torture as well as that the form of waterboarding used by the CIA was far more intense than authorized by the Justice Department.

North Korea condemnation

Bush publicly condemned Kim Jong-il of North Korea and identified North Korea as one of three states in an "axis of evil". He said that "the United States of America will not permit the world's most dangerous regimes to threaten us with the world's most destructive weapons." Within months, "both countries had walked away from their respective commitments under the U.S.–DPRK Agreed Framework of October 1994." North Korea's October 9, 2006, detonation of a nuclear device further complicated Bush's foreign policy, which centered for both terms of his presidency on "[preventing] the terrorists and regimes who seek chemical, biological, or nuclear weapons from threatening the United States and the world".

Bush condemned North Korea's position, reaffirmed his commitment to "a nuclear-free Korean Peninsula", and said that "transfer of nuclear weapons or material by North Korea to states or non-state entities would be considered a grave threat to the United States", for which North Korea would be held accountable. On May 7, 2007, North Korea agreed to shut down

its nuclear reactors immediately pending the release of frozen funds held in a foreign bank account. This was a result of a series of three-way talks initiated by the United States and including China. On September 2, 2007, North Korea agreed to disclose and dismantle all its nuclear programs by the end of 2007. By May 2009, North Korea had restarted its nuclear program and threatened to attack South Korea.

On June 22, 2010, "While South Korea prospers, the people of North Korea have suffered profoundly," he said, adding that communism had resulted in dire poverty, mass starvation and brutal suppression. "In recent years," he went on to say, "the suffering has been compounded by the leader who wasted North Korea's precious few resources on personal luxuries and nuclear weapons programs."

Syria sanctions

Bush expanded economic sanctions on Syria. In 2003, Bush signed the Syria Accountability Act, which expanded sanctions on Syria. In early 2007, the Treasury Department, acting on a June 2005 executive order, froze American bank accounts of Syria's Higher Institute of Applied Science and Technology, Electronics Institute, and National Standards and Calibration Laboratory. Bush's order prohibits Americans from doing business with these institutions suspected of helping spread weapons of mass destruction and being supportive of terrorism. Under separate executive orders signed by Bush in 2004 and later 2007, the Treasury Department froze the assets of two Lebanese and two Syrians, accusing them of activities to "undermine the legitimate political process in Lebanon" in November 2007. Those designated included: Assaad Halim

Hardan, a member of Lebanon's parliament and current leader of the Syrian Socialist National Party; Wi'am Wahhab, a former member of Lebanon's government (Minister of the Environment) under Prime Minister Omar Karami (2004–2005); Hafiz Makhluf, a colonel and senior official in the Syrian General Intelligence Directorate and a cousin of Syrian President Bashar al-Assad; and Muhammad Nasif Khayrbik, identified as a close adviser to Assad.

PEPFAR

In the State of the Union address in January 2003, Bush outlined a five-year strategy for global emergency AIDS relief, the President's Emergency Plan for AIDS Relief (PEPFAR). Bush announced $15 billion for this effort which directly supported life-saving antiretroviral treatment for more than 3.2 million men, women and children worldwide.

The U.S. government had spent some $44 billion on the project since 2003 (a figure that includes $7 billion contributed to the Global Fund to Fight AIDS, Tuberculosis, and Malaria, a multilateral organization), which saved an estimated five million lives. According to *The New York Times* correspondent Peter Baker, "Bush did more to stop AIDS and more to help Africa than any president before or since."

Assassination attempt

On May 10, 2005, Vladimir Arutyunian, a native Georgian who was born to a family of ethnic Armenians, threw a live hand grenade toward a podium where Bush was speaking at Freedom Square in Tbilisi, Georgia. Georgian President Mikheil

Saakashvili was seated nearby. It landed in the crowd about 65 feet (20 m) from the podium after hitting a girl, but it did not detonate. Arutyunian was arrested in July 2005, confessed, was convicted and was given a life sentence in January 2006.

Other issues

Bush signed the Strategic Offensive Reductions Treaty with Russia. He withdrew U.S. support for several international agreements, including the Anti-Ballistic Missile Treaty (ABM) with Russia.

Bush emphasized a careful approach to the conflict between Israel and the Palestinians; he denounced Palestine Liberation Organization leader Yasser Arafat for his support of violence, but sponsored dialogues between Prime Minister Ariel Sharon and Palestinian National Authority President Mahmoud Abbas. Bush supported Sharon's unilateral disengagement plan, and lauded the democratic elections held in Palestine after Arafat's death.

In July 2001, Bush visited Pope John Paul II at Castel Gandolfo.

Bush also expressed U.S. support for the defense of Taiwan following the stand-off in April 2001 with China over the Hainan Island incident, when an EP-3E Aries II surveillance aircraft collided with a People's Liberation Army Air Force jet, leading to the detention of U.S. personnel.

From 2003 to 2004, Bush authorized U.S. military intervention in Haiti and Liberia to protect U.S. interests. Bush condemned the militia attacks Darfur and denounced the killings in Sudan

as genocide. Bush said an international peacekeeping presence was critical in Darfur, but he opposed referring the situation to the International Criminal Court.

On June 10, 2007, Bush met with Albanian Prime Minister Sali Berisha and became the first president to visit Albania. Bush has voiced his support for the independence of Kosovo. Bush opposed South Ossetia's independence. On August 15, 2008, Bush said of Russia's invasion of the country of Georgia: "Bullying and intimidation are not acceptable ways to conduct foreign policy in the 21st century."

Bush opened the 2002 Winter Olympics in Salt Lake City, Utah. Departing from previous practice, he stood among a group of U.S. athletes rather than from a ceremonial stand or box, saying: "On behalf of a proud, determined, and grateful nation, I declare open the Games of Salt Lake City, celebrating the Olympic Winter Games." In 2008, in the course of a good-will trip to Asia, he attended the Summer Olympics in Beijing.

Bush twice invoked Section 3 of the Twenty-fifth Amendment, which allows a president to temporarily transfer the powers and duties of his office to the vice president, who then becomes acting president. On June 29, 2002, Bush underwent a colonoscopy and invoked the provision, making Vice President Cheney the acting president. Bush was awake and resumed his presidential powers after two hours. On July 21, 2007, Bush again invoked the provision in preparation for another colonoscopy. Again, Bush resumed his presidential powers after two hours.

Judicial appointments

Supreme Court

On July 19, 2005, following the announcement of the retirement of Associate Justice Sandra Day O'Connor on July 1, Bush nominated federal appellate judge John Roberts to be O'Connor's replacement; however, following the death of Chief Justice William Rehnquist on September 3, that still-pending nomination was withdrawn on September 5, with Bush instead nominating Roberts to be the next Chief Justice of the United States. He was confirmed by the Senate on September 29, 2005.

On October 3, 2005, Bush nominated White House Counsel Harriet Miers to succeed O'Connor; however, Miers withdrew her nomination on October 27 after encountering significant opposition from both parties, who found her to be ill-prepared and uninformed on the law, once again leaving no nominee to replace O‘Connor.

Finally, on October 31, Bush nominated federal appellate judge Samuel Alito, who was confirmed by the Senate to replace O'Connor on January 31, 2006.

Other courts

In addition to his two Supreme Court appointments, Bush appointed 61 judges to the United States courts of appeals and 261 judges to the United States district courts. Each of these numbers, along with his 324 judicial appointments.

Cultural and political image

Image

Bush's upbringing in West Texas, his accent, his vacations on his Texas ranch, and his penchant for country metaphors contribute to his folksy, American cowboy image. "I think people look at him and think John Wayne", said Piers Morgan, editor of the British *Daily Mirror*.

Bush has been parodied by the media, comedians, and other politicians. Detractors tended to cite linguistic errors made by Bush during his public speeches, which are colloquially referred to as Bushisms.

In contrast to his father, who was perceived as having troubles with an overarching unifying theme, Bush embraced larger visions and was seen as a man of larger ideas and associated huge risks. Tony Blair wrote in 2010 that the caricature of Bush as being dumb is "ludicrous" and that Bush is "very smart". In an interview with *Playboy*, *The New York Times* columnist David Brooks said Bush "was 60 IQ points smarter in private than he was in public. He doesn't want anybody to think he's smarter than they are, so puts on a Texas act."

Job approval

Bush began his presidency with approval ratings near 50 percent. After the September 11 attacks, Bush gained an approval rating of 90 percent, maintaining 80–90 percent approval for four months after the attacks. It remained over 50 percent during most of his first term and then fell to as low as 19 percent in his second term.

In 2000 and again in 2004, *Time* magazine named George W. Bush as its Person of the Year, a title awarded to someone who the editors believe "has done the most to influence the events of the year". In May 2004, Gallup reported that 89 percent of the Republican electorate approved of Bush. However, the support waned due mostly to a minority of Republicans' frustration with him on issues of spending, illegal immigration, and Middle Eastern affairs. Within the United States armed forces, according to an unscientific survey, the president was strongly supported in the 2004 presidential elections. While 73 percent of military personnel said they would vote for Bush, 18 percent preferred his Democratic rival, John Kerry. According to Peter Feaver, a Duke University political scientist who has studied the political leanings of the U.S. military, members of the armed services supported Bush because they found him more likely than Kerry to complete the War in Iraq.

Bush's approval rating went below the 50 percent mark in AP-Ipsos polling in December 2004. Thereafter, his approval ratings and approval of his handling of domestic and foreign policy issues steadily dropped. After his re-election in 2004, Bush received increasingly heated criticism from across the political spectrum for his handling of the Iraq War, his response to Hurricane Katrina, and to the Abu Ghraib prisoner abuse, NSA warrantless surveillance, the Plame affair, and Guantanamo Bay detention camp controversies.

Amid this criticism, the Democratic Party regained control of Congress in the 2006 elections. Polls conducted in 2006 showed an average of 37 percent approval ratings for Bush, the lowest for any second-term president at that point in his term since Harry S. Truman in March 1951 (when Truman's

approval rating was 28 percent), which contributed to what Bush called the "thumping" of the Republican Party in the 2006 mid-term elections. Throughout most of 2007, Bush's approval rating hovered in the mid-thirties; the average for his entire second term was 37 percent, according to Gallup.

By the beginning of 2008, his final year in office, Bush's approval rating had dropped to a low of just 19 percent, largely from the loss of support among Republicans. Commenting on his low poll numbers and accusations of being "the worst president," Bush would say, "I make decisions on what I think is right for the United States based upon principles. I frankly don't give a damn about the polls."

There were calls for Bush's impeachment, though most polls showed a plurality of Americans would not support such an action. The arguments offered for impeachment usually centered on the NSA warrantless surveillance controversy, the Bush administration's justification for the war in Iraq, and alleged violations of the Geneva Conventions. Representative Dennis Kucinich (D-OH), who had run against Bush during the 2004 presidential campaign, introduced 35 articles of impeachment on the floor of the House of Representatives against Bush on June 9, 2008, but Speaker Nancy Pelosi (D-CA) declared that impeachment was "off the table".

In April 2008, Bush's disapproval ratings reached the highest ever recorded for any president in the 70-year history of the Gallup poll, with 69 percent of those polled disapproving of the job Bush was doing as president and 28 percent approving – although the majority (66 percent) of Republicans still approved of his job performance.

In polls conducted in the fall, just before the 2008 election, his approval ratings remained at record lows of 19 to 20 percent, while his disapproval ratings ranged from 67 percent to as high as 75 percent. In polling conducted January 9–11, 2009, his final job approval rating by Gallup was 34 percent, which placed him on par with Jimmy Carter and Harry S. Truman, the other presidents whose final Gallup ratings measured in the low 30s (Richard Nixon's final Gallup approval rating was even lower, at 24 percent). According to a CBS News/*New York Times* poll conducted January 11–15, 2009, Bush's final approval rating in office was 22 percent, the lowest in American history.

Foreign perceptions

Bush was criticized internationally and targeted by the global anti-war and anti-globalization movements for his administration's foreign policy. Views of him within the international community – even in France, a close ally of the United States – were more negative than those of most previous American presidents.

Bush was described as having especially close personal relationships with Tony Blair of the United Kingdom and Vicente Fox of Mexico, although formal relations were sometimes strained. Other leaders, such as Hamid Karzai of Afghanistan, Yoweri Museveni of Uganda, José Luis Rodríguez Zapatero of Spain, and Hugo Chávez of Venezuela, openly criticized the president. Later in Bush's presidency, tensions arose between him and Vladimir Putin, which led to a cooling of their relationship.

In 2006, most respondents in 18 of 21 countries surveyed around the world were found to hold an unfavorable opinion of Bush. Respondents indicated that they judged his administration as negative for world security. In 2007, the Pew Global Attitudes Project reported that during the Bush presidency, attitudes towards the United States, and towards Americans, became less favorable around the world.

The Pew Research Center's 2007 Global Attitudes poll found that in only nine countries of 47 did most respondents express "a lot of confidence" or "some confidence" in Bush: Ethiopia, Ghana, India, Israel, Ivory Coast, Kenya, Mali, Nigeria, and Uganda.

A March 2007 survey of Arab opinion conducted by Zogby International and the University of Maryland found that Bush was the most disliked leader in the Arab world.

During a June 2007 visit to the predominantly Muslim Albania, Bush was greeted enthusiastically. Albania has a population of 2.8 million, has troops in both Iraq and Afghanistan, and the country's government is highly supportive of American foreign policy. A huge image of the President was hung in the middle of the capital city of Tirana flanked by Albanian and American flags while a local street was named after him. A shirt-sleeved statue of Bush was unveiled in Fushë-Krujë, a few kilometers northwest of Tirana. The Bush administration's support for the independence of Albanian-majority Kosovo, while endearing him to the Albanians, has troubled U.S. relations with Serbia, leading to the February 2008 torching of the U.S. embassy in Belgrade.

Acknowledgments and dedications

On May 7, 2005, during an official state visit to Latvia, Bush was awarded the Order of the Three Stars presented to him by President Vaira Vīķe-Freiberga. A few places outside the United States bear Bush's name. In 2005, the Tbilisi City Council voted to rename a street in honor of the U.S. president. Previously known as Melaani Drive, the street links the Georgian capital's airport with the city center and was used by Bush's motorcade during his visit four months earlier. A street in Tirana, formerly known as *Rruga Punëtorët e Rilindjes*, situated directly outside the Albanian Parliament, was renamed after Bush a few days before he made the first-ever visit by an American president to Albania in June 2007. In Jerusalem, a small plaza with a monument bearing his name is also dedicated to Bush. In 2012, Estonian President Toomas Hendrik Ilves awarded Bush the Order of the Cross of Terra Mariana for his work in expanding NATO.

Two elementary schools are named after him: George W. Bush Elementary School of the Stockton Unified School District in Stockton, California, and George W. Bush Elementary School of the Wylie Independent School District in St. Paul, Texas, in the Dallas-Fort Worth area.

Post-presidency (2009–present)

Residence

Following the inauguration of Barack Obama, Bush and his family flew from Andrews Air Force Base to a homecoming

celebration in Midland, Texas, following which they returned to their ranch in Crawford, Texas. They bought a home in the Preston Hollow neighborhood of Dallas, Texas, where they settled down.

He makes regular appearances at various events throughout the Dallas/Fort Worth area, most notably when he conducted the opening coin toss at the Dallas Cowboys first game in the team's new stadium in Arlington and an April 2009 visit to a Texas Rangers game, where he thanked the people of Dallas for helping him settle in and was met with a standing ovation. He also attended every home playoff game for the Texas Rangers 2010 season and, accompanied by his father, threw out the ceremonial first pitch at Rangers Ballpark in Arlington for Game 4 of the 2010 World Series on October 31, 2010.

On August 6, 2013, Bush was successfully treated for a coronary artery blockage with a stent. The blockage had been found during an annual medical examination.

In reaction to the 2016 shooting of Dallas police officers, Bush stated: "Laura and I are heartbroken by the heinous acts of violence in our city last night. Murdering the innocent is always evil, never more so than when the lives taken belong to those who protect our families and communities."

Publications and appearances

- Since leaving office, Bush has kept a relatively low profile though he has made public appearances, most notably after the release of his memoirs in 2010 and for the 10th anniversary of the September 11 attacks in 2011. In March 2009, he delivered his

first post-presidency speech in Calgary, Alberta, appeared via video on *The Colbert Report* during which he praised U.S. troops for earning a "special place in American history," and attended the funeral of Senator Ted Kennedy. Bush made his debut as a motivational speaker on October 26 at the "Get Motivated" seminar in Dallas. In the aftermath of the Fort Hood shooting on November 5, 2009, the Bushes paid an undisclosed visit to the survivors and the victims' families the day following the shooting, having contacted the base commander requesting that the visit be private and not involve press coverage.

Bush released his memoirs, *Decision Points*, on November 9, 2010. During a pre-release appearance promoting the book, Bush said he considered his biggest accomplishment to be keeping "the country safe amid a real danger", and his greatest failure to be his inability to secure the passage of Social Security reform. He also made news defending his administration's enhanced interrogation techniques, specifically the waterboarding of Khalid Sheikh Mohammed, saying, "I'd do it again to save lives."

In 2012, he wrote the foreword of *The 4% Solution: Unleashing the Economic Growth America Needs*, an economics book published by the George W. Bush Presidential Center. He also presented the book at the Parkland Memorial Hospital in Dallas, Texas.

Bush appeared on NBC's *The Tonight Show with Jay Leno* on November 19, 2013, along with the former First Lady, Laura

Bush. When asked by Leno why he does not comment publicly about the Obama administration, Bush said, "I don't think it's good for the country to have a former president criticize his successor." Despite this statement, Bush vocally disagreed with Obama's withdrawal of U.S. troops from Iraq in 2011, calling it a "strategic blunder", borrowing a term that had been used by South Carolina Senator Lindsey Graham.

In 2013, Bush and his wife Laura travelled with then President Obama and Michelle Obama to the memorial service of South African President and civil rights leader Nelson Mandela. There they joined former Presidents Clinton and Carter.

Alongside the 2014 United States–Africa Leaders Summit, Bush, Michelle Obama, the State Department, and the George W. Bush Institute hosted a daylong forum on education and health with the spouses of the African leaders attending the summit. Bush urged African leaders to avoid discriminatory laws that make the treatment of HIV/AIDS more difficult.

Bush has spoken in favor of increased global participation of women in politics and societal matters in foreign countries.

On November 2, 2014, Bush spoke at an event to 200 business and civic leaders at the George W. Bush Presidential Library and Museum to raise awareness for the upcoming Museum of the Bible in Washington D.C.

Bush published a biography of his father, George Bush, called *41: A Portrait of My Father*. It was released on November 11, 2014.

In an interview published by *Israel Hayom* magazine on June 12, 2015, Bush said "boots on the ground" would be needed in order to defeat the Islamic State of Iraq and the Levant (ISIS). He added that people had said during his presidency that he should withdraw American troops from Iraq, but he chose the opposite, sending 30,000 more troops in order to defeat Al Qaeda in Iraq, and that they indeed were defeated. Bush was also asked about Iran but declined to answer, stating that any answer he gives would be interpreted as undermining Obama.

In February 2016, George W. Bush spoke and campaigned for his brother Jeb Bush in South Carolina during a rally for the Jeb Bush presidential campaign in the 2016 Republican Party presidential primaries.

While Bush endorsed the Republican Party's 2012 presidential nominee, Mitt Romney, he declined to endorse the 2016 Republican nominee, Donald Trump. Also, Bush attended neither the 2012 nor the 2016 Republican National Conventions, where Romney and Trump, respectively, were formally nominated. On the eve of Trump's nomination, it was reported that Bush had privately expressed concern about the current direction of the Republican Party and told a group of his former aides and advisors, "I'm worried that I will be the last Republican president." Bush and his wife Laura did not vote for Trump in the 2016 presidential election according to a spokesperson for the Bush family, instead choosing to leave their presidential ballots blank. After the election, Bush, his father, and his brother Jeb called Trump on the phone to congratulate him on his victory. Both he and Laura attended Trump's inauguration, and images of Bush struggling to put on a rain poncho during the ceremony became an internet meme.

While leaving the event, Bush allegedly described the ceremony, in particular Trump's inaugural address, as "some weird shit".

In February 2017, Bush released a book of his own portraits of veterans called *Portraits of Courage* (full title: *Portraits of Courage: A Commander in Chief's Tribute to America's Warriors*).

Following the white nationalist Unite the Right rally in Charlottesville, Virginia, Bush and his father released a joint statement condemning the violence and ideologies present at the rally; "America must always reject racial bigotry, anti-Semitism, and hatred in all forms. As we pray for Charlottesville, we are all reminded of the fundamental truths recorded by that city's most prominent citizen in the Declaration of Independence: we are all created equal and endowed by our Creator with unalienable rights. We know these truths to be everlasting because we have seen the decency and greatness of our country." Their statement came as President Trump was facing controversy over his statements about the rally. Subsequently, Bush gave a speech in New York where he noted of the current political climate, "Bigotry seems emboldened. Our politics seems more vulnerable to conspiracy theories and outright fabrication." He continued, "Bigotry in any form is blasphemy against the American creed and it means the very identity of our nation depends on the passing of civic ideals to the next generation," while urging citizens to oppose threats to American democracy and be positive role models for young people. The speech was widely interpreted as a denouncement of Donald Trump and his ideologies, despite Bush not mentioning Trump by name.

In April 2018, Bush and his father met in Texas with Mohammad bin Salman, the crown prince and de facto ruler of Saudi Arabia.

In May 2019, on the 10th anniversary of former South Korean president Roh Moo-hyun's passing, George Bush visited South Korea to pay respects to Roh and gave a short eulogy.

On June 1, 2020, Bush released a statement addressing the murder of George Floyd and the subsequent nationwide reaction and protests. In the statement, Bush wrote that he and former first lady Laura Bush "are anguished by the brutal suffocation of George Floyd and disturbed by the injustice and fear that suffocate our country". He also elaborated on the racial injustices perpetrated by the police saying, that "it is time for America to examine our tragic failures", adding "Many doubt the justice of our country, and with good reason. Black people see the repeated violation of their rights without an urgent and adequate response from American institutions".

On July 30, 2020 Both George Bush and his wife Laura Bush, along with former Presidents Bill Clinton and Barack Obama, attended and spoke at the funeral for civil rights leader and congressman John Lewis at Ebenezer Baptist Church in Atlanta. At the service Bush stated in his remarks, "We live in a better and nobler country today because of John Lewis and his abiding faith in the power of God, the power of democracy and in the power of love to lift us all to a higher ground ... The story that began in true isn't ending today, nor is the work."

Bush did not give any endorsements during the 2020 presidential election. He also did not attend the 2020 Republican National Convention where President Trump was

re-nominated. He told People magazine in April 2021 that he did not vote for either Trump or Biden in the November election. Instead, Bush wrote in Condoleezza Rice, who served as his secretary of state from 2005 to 2009.

When the election was called for Democratic candidate Joe Biden on November 7, 2020, Bush offered his congratulations to Biden and his running mate Kamala Harris the following day, and congratulated Trump and his supporters "on a hard-fought campaign". Bush's outreach to Biden was notable since Republican candidate Donald Trump had not yet conceded. Bush then issued a statement saying that while Trump was within his rights to call for recounts, he believed the election was "fundamentally fair" and that "its outcome is clear", and said he would offer Biden "my prayers for his success, and my pledge to help in any way I can", as he had for Trump and Obama.

Despite not making any presidential endorsements in 2020, he did, however, hold a virtual fundraiser for U.S. Senators Susan Collins (R-ME), Cory Gardner (R-CO), Martha McSally (R-AZ), and Thom Tillis (R-NC). All four were up for reelection and were struggling in the polls. Collins and Tillis were reelected, while Gardner and McSally were not.

On January 6, 2021, following the 2021 storming of the United States Capitol, Bush denounced the violence and attack on the U.S. Capitol alongside the three other living former presidents, Barack Obama, Bill Clinton, Jimmy Carter, releasing a statement saying that "this is how election results are disputed in a banana republic, not our democratic republic" and that “it is a sickening and heartbreaking sight”. He also echoed

President-elect Joe Biden's message stating that what occurred at the capital was an "insurrection." On January 20, 2021, Bush and Laura attended the inauguration of Joe Biden, alongside Barack Obama, Michelle Obama, Bill Clinton and Hillary Clinton.

Bush opposed the 2021 withdrawal of U.S. troops from Afghanistan under President Biden, saying that the withdrawal made him "concerned" and that he believed it had the potential to "create a vacuum, and into that vacuum is likely to come people who treat women as second class citizens". During an interview with Deutsche Welle on July 14, 2021, Bush reaffirmed his opposition to the troop withdrawal, calling the plan "a mistake".

Collaborations

In January 2010, at President Obama's request, Bush and Bill Clinton established the Clinton Bush Haiti Fund to raise contributions for relief and recovery efforts following the 2010 Haiti earthquake earlier that month.

On May 2, 2011, President Obama called Bush, who was at a restaurant with his wife, to inform him that Osama bin Laden had been killed.

The Bushes joined the Obamas in New York City to mark the tenth anniversary of the September 11, 2001, terrorist attacks. At the Ground Zero memorial, Bush read a letter that President Abraham Lincoln wrote to a widow who had lost five sons during the Civil War.

On September 7, 2017, Bush partnered with former presidents Jimmy Carter, George H. W. Bush, Bill Clinton, and Barack Obama to work with One America Appeal to help the victims of Hurricane Harvey and Hurricane Irma in the Gulf Coast and Texas communities.

Over the years, President Bush has had a good-natured friendship with Michelle Obama. "President Bush and I, we are forever seatmates because of protocol, and that's how we sit at all the official functions," Mrs. Obama told the *Today Show*. "He's my partner in crime at every major thing where all the 'formers' gather. So we're together all the time." She later added, "I love him to death. He's a wonderful man, he's a funny man." Bush and Obama have sat next to each other at many events including the 50th anniversary of the historic civil rights march in Selma (2015), the interfaith memorial service for the victims in Dallas (2016), the opening at the National Museum of African American History and Culture (2016), and at the funerals for Nancy Reagan (2016), and John McCain (2018). Bush famously passed mints to Mrs. Obama during the McCain funeral in September 2018 and gave them to her again during the funeral of his father in December 2018.

Art

After serving as president, Bush began painting as a hobby after reading Winston Churchill's essay "Painting as a Pastime." Subjects have included people, dogs, and still life. He has also painted self-portraits and portraits of world leaders, including Vladimir Putin and Tony Blair. In February 2017, Bush released a book of portraits of veterans, *Portraits of Courage*. The net proceeds from his book are donated to the

George W. Bush Presidential Center. In May 2019, on the 10th anniversary of former South Korean president Roh Moo-hyun's passing, George Bush drew a portrait of Roh to give to his family.

Honors

- Main article: List of honors and awards received by George W. Bush
- Albania:
- Recipient of the National Flag Order (June 10, 2007)
- Benin:
- Grand Cross of the National Order of Benin (February 16, 2008)
- Estonia:
- First Class of the Order of the Cross of Terra Mariana (February 1, 2002)
- Latvia:
- Commander Grand Cross with Chain of the Order of the Three Stars (May 7, 2005)
- Liberia:
- Grand Cordon of the Order of the Pioneers of Liberia (February 21, 2008)
- Saudi Arabia:
- Collar of the Order of King Abdulaziz (January 14, 2008)

In popular culture

Legacy

President Bush's legacy continues to develop today. Supporters credit Bush's counterterrorism policies with preventing another major terrorist attack from occurring in the U.S. after 9/11 and also praise individual policies such as the Medicare prescription drug benefit and the AIDS relief program known as PEPFAR. Critics often point to his handling of the Iraq War, specifically the failure to find weapons of mass destruction, as well as his handling of tax policy, Hurricane Katrina, climate change and the 2008 financial crisis, as proof that George W. Bush was unfit to be president.

Several historians and commentators hold that Bush was one of the most consequential presidents in American history. Princeton University scholar Julian Zelizer described Bush's presidency as a "transformative" one, and said that "some people hate him, some people love him, but I do think he'll have a much more substantive perception as time goes on". Bryon Williams of *The Huffington Post* referred to Bush as "the most noteworthy president since FDR" and said the Patriot Act "increased authority of the executive branch at the expense of judicial opinions about when searches and seizures are reasonable" as evidence. Bush's administration presided over the largest tax cuts since the presidency of Ronald Reagan, and his homeland security reforms proved to be the most significant expansion of the federal government since the Great Society. Much of these policies have endured in the administrations of his two immediate successors, Barack Obama and Donald Trump.

Reception

The George W. Bush presidency has been ranked as below-average in surveys of presidential scholars published in the late 2000s and 2010s.

A 2010 Siena Research Institute survey of the opinions of historians, political scientists, and presidential scholars ranked him 39th out of 43 presidents. The survey respondents gave President Bush low ratings on his handling of the U.S. economy, communication, ability to compromise, foreign policy accomplishments, and intelligence. Bush said in 2013, "Ultimately history will judge the decisions I made, and I won't be around because it will take time for the objective historians to show up. So I am pretty comfortable with it. I did what I did." C-SPAN's 2021 survey of historians ranked Bush as the 29th-best president; Bush had initially been ranked the 36th in 2009.

Among the public, his reputation has improved since his presidency ended in 2009. In February 2012, Gallup reported that "Americans still rate George W. Bush among the worst presidents, though their views have become more positive in the three years since he left office." Gallup had earlier noted that Bush's favorability ratings in public opinion surveys had begun to rise a year after he had left office, from 40 percent in January 2009 and 35 percent in March 2009, to 45 percent in July 2010, a period during which he had remained largely out of the news. A poll conducted in June 2013 marked the first time recorded by Gallup where his ratings have been more positive than negative, with 49 percent viewing him favorably compared to 46 percent unfavorably. Other pollsters have

noted similar trends of slight improvement in Bush's personal favorability since the end of his presidency.

In April 2013, Bush's approval rating stood at 47 percent approval and 50 percent disapproval in a poll jointly conducted for *The Washington Post* and ABC, his highest approval rating since December 2005. Bush had achieved notable gains among seniors, non-college whites, and moderate and conservative Democrats since leaving office, although majorities disapproved of his handling of the economy (53 percent) and the Iraq War (57 percent).

His 47 percent approval rating was equal to that of President Obama's in the same polling period. A CNN poll conducted that same month found that 55 percent of Americans said Bush's presidency had been a failure, with opinions divided along party lines, and 43 percent of independents calling it a success. Bush's public image saw greater improvement in 2017, with a YouGov survey showing 51 percent of favorability from Democrats. A 2018 CNN poll subsequently found that 61 percent of respondents held of a favorable view of Bush, an increase of nine points from 2015. The improvement has been interpreted as Democrats viewing him more favorably in response to Donald Trump's presidency, an assessment that has also been expressed by Bush himself.

India–United States Civil Nuclear Agreement

The **123 Agreement** signed between the United States of America and the Republic of India is known as the **U.S.–India**

Civil Nuclear Agreement or **Indo-US nuclear deal**. The framework for this agreement was a July 18, 2005, joint statement by then Indian Prime Minister Dr.Manmohan Singh and then U.S. President George W. Bush, under which India agreed to separate its civil and military nuclear facilities and to place all its civil nuclear facilities under International Atomic Energy Agency (IAEA) safeguards and, in exchange, the United States agreed to work toward *full* civil nuclear cooperation with India.

This U.S.-India deal took more than three years to come to fruition as it had to go through several complex stages, including amendment of U.S. domestic law, especially the Atomic Energy Act of 1954, a civil-military nuclear *Separation Plan* in India, an India-IAEA safeguards (inspections) agreement and the grant of an exemption for India by the Nuclear Suppliers Group, an export-control cartel that had been formed mainly in response to India's first nuclear test in 1974. In its final shape,

the deal places under permanent safeguards those nuclear facilities that India has identified as "civil" and permits broad civil nuclear cooperation, while excluding the transfer of "sensitive" equipment and technologies, including civil enrichment and reprocessing items even under IAEA safeguards. On August 18, 2008 the IAEA Board of Governors approved, and on February 2, 2009, India signed an India-specific safeguards agreement with the IAEA. After India brought this agreement into force, inspections began in a phased manner on the 35 civilian nuclear installations India has identified in its Separation Plan. The deal is seen as a watershed in U.S.-India relations and introduces a new aspect

to international nonproliferation efforts. On August 1, 2008, the IAEA approved the safeguards agreement with India, after which the United States approached the Nuclear Suppliers Group (NSG) to grant a waiver to India to commence civilian nuclear trade.

The 48-nation NSG granted the waiver to India on September 6, 2008 allowing it to access civilian nuclear technology and fuel from other countries. The implementation of this waiver made India the only known country with nuclear weapons which is not a party to the Non-Proliferation Treaty (NPT) but is still allowed to carry out nuclear commerce with the rest of the world.

The U.S. House of Representatives passed the bill to approve the deal on September 28, 2008. Two days later, India and France inked a similar nuclear pact making France the first country to have such an agreement with India. On October 1, 2008 the U.S. Senate also approved the civilian nuclear agreement allowing India to purchase nuclear fuel and technology from—and sell them to—the United States. U.S. president, George W. Bush, signed the legislation on the Indo-US nuclear deal, approved by the U.S. Congress, into law, now called the **United States-India Nuclear Cooperation Approval and Non-proliferation Enhancement Act**, on October 8, 2008. The agreement was signed by then Indian External Affairs Minister Pranab Mukherjee and his counterpart then Secretary of State Condoleezza Rice, on October 10.

In 2015, the agreement had still not been fully implemented.

In 2016, the countries agreed to build 6 US-designed reactors in India. See timeline below.

The *Henry J. Hyde United States-India Peaceful Atomic Energy Cooperation Act of 2006*, also known as the *Hyde Act*, is the U.S. domestic law that modifies the requirements of Section 123 of the U.S. Atomic Energy Act to permit nuclear cooperation with India and in particular to negotiate a 123 Agreement to operationalize the 2005 Joint Statement. As a domestic U.S. law, the Hyde Act is binding on the United States. The Hyde Act cannot be binding on India's sovereign decisions although it can be construed as prescriptive for future U.S. reactions. As per the Vienna Convention, an international agreement such as the 123 Agreement cannot be superseded by an internal law such as the Hyde Act.

The 123 agreement defines the terms and conditions for bilateral civilian nuclear cooperation, and requires separate approvals by the U.S. Congress and by Indian cabinet ministers. The agreement will also help India meet its goal of adding 25,000 MW of nuclear power capacity through imports of nuclear reactors and fuel by 2020.

After the terms of the 123 agreement were concluded on July 27, 2007, it ran into trouble because of stiff opposition in India from the communist allies of the ruling United Progressive Alliance. The government survived a confidence vote in the parliament on July 22, 2008 by 275–256 votes in the backdrop of defections by some parties . The deal also had faced opposition from non-proliferation activists, anti-nuclear organisations, and some states within the Nuclear Suppliers Group. In February 2008, U.S. Secretary of State Condoleezza Rice said that any agreement would be "consistent with the obligations of the Hyde Act". The bill was signed on October 8, 2008.

Background

Parties to the Non-Proliferation Treaty (NPT) have a recognized right of access to peaceful uses of nuclear energy and an obligation to cooperate on civilian nuclear technology. Separately, the Nuclear Suppliers Group has agreed on guidelines for nuclear exports, including reactors and fuel. Those guidelines condition such exports on comprehensive safeguards by the International Atomic Energy Agency, which are designed to verify that nuclear energy is not diverted from peaceful use to weapons programs.

Though neither India, Israel, nor Pakistan have signed the NPT, India argues that instead of addressing the central objective of universal and comprehensive non-proliferation, the treaty creates a club of "nuclear haves" and a larger group of "nuclear have-nots" by restricting the legal possession of nuclear weapons to those states that tested them before 1967, who alone are free to possess and multiply their nuclear stockpiles. India insists on a comprehensive action plan for a nuclear-free world within a specific time-frame and has also adopted a voluntary "no first use policy".

Led by the U.S., other states have set up an informal group, the Nuclear Suppliers Group (NSG), to control exports of nuclear materials, equipment and technology. Consequently, India was left outside the international nuclear order, which forced India to develop its own resources for each stage of the nuclear fuel cycle and power generation, including next generation reactors such as fast breeder reactors and a thorium breeder reactor known as the Advanced Heavy Water Reactor. In addition to impelling India to achieve success in

developing these new reactor technologies, the sanctions also provided India with the impetus to continue developing its own nuclear weapons technology with a specific goal of achieving self-sufficiency for all key components for weapons design, testing and production.

Given that India is estimated to possess reserves of about 80,000–112,369 tons of uranium, India has more than enough fissile material to supply its nuclear weapons program, even if it restricted Plutonium production to only 8 of the country's 17 current reactors, and then further restricted Plutonium production to only 1/4 of the fuel core of these reactors. According to the calculations of one of the key advisers to the US Nuclear deal negotiating team, Ashley Tellis:

Operating India's eight unsafeguarded PHWRs in such a [conservative] regime would bequeath New Delhi with some 12,135–13,370 kilograms of weapons-grade plutonium, which is sufficient to produce between 2,023–2,228 nuclear weapons over and above those already existing in the Indian arsenal. Although no Indian analyst, let alone a policy maker, has ever advocated any nuclear inventory that even remotely approximates such numbers, this heuristic exercise confirms that New Delhi has the capability to produce a gigantic nuclear arsenal while subsisting well within the lowest estimates of its known uranium reserves.

However, because the amount of nuclear fuel required for the electricity generation sector is far greater than that required to maintain a nuclear weapons program, and since India's estimated reserve of uranium represents only 1% of the world's known uranium reserves, the NSG's uranium export

restrictions mainly affected Indian nuclear power generation capacity. Specifically, the NSG sanctions challenge India's long-term plans to expand and fuel its civilian nuclear power generation capacity from its current output of about 4GWe (GigaWatt electricity) to a power output of 20GWe by 2020; assuming the planned expansion used conventional Uranium/Plutonium fueled heavy water and light water nuclear power plants.

Consequently, India's nuclear isolation constrained expansion of its civil nuclear program, but left India relatively immune to foreign reactions to a prospective nuclear test. Partly for this reason, but mainly due to continued unchecked covert nuclear and missile proliferation activities between Pakistan, China and North Korea, India conducted five more nuclear tests in May 1998 at Pokhran.

India was subject to international sanctions after its May 1998 nuclear tests. However, due to the size of the Indian economy and its relatively large domestic sector, these sanctions had little impact on India, with Indian GDP growth increasing from 4.8% in 1997–1998 (prior to sanctions) to 6.6% (during sanctions) in 1998–1999.

Consequently, at the end of 2001, the Bush Administration decided to drop all sanctions on India. Although India achieved its strategic objectives from the Pokhran nuclear tests in 1998, it continued to find its civil nuclear program isolated internationally.

Rationale behind the agreement

Nuclear non-proliferation

The proposed civil nuclear agreement implicitly recognizes India's "de facto" status even without signing the NPT. The Bush administration justifies a nuclear pact with India arguing that it is important in helping to advance the non-proliferation framework by formally recognizing India's strong non-proliferation record even though it has not signed the NPT.

The former Under Secretary of State of Political Affairs, Nicholas Burns, one of the architects of the Indo-U.S. nuclear deal said "India's trust, its credibility, the fact that it has promised to create a state-of-the-art facility, monitored by the IAEA, to begin a new export control regime in place, because it has not proliferated the nuclear technology, we can't say that about Pakistan." when asked whether the U.S. would offer a nuclear deal with Pakistan on the lines of the Indo-U.S. deal. Mohamed ElBaradei, former head of the International Atomic Energy Agency, which would be in charge of inspecting India's civilian reactors has praised the deal as "it would also bring India closer as an important partner in the nonproliferation regime".

The reaction in the U.S. led academic community was mixed. While some authors praised the agreement as bringing India closer to the NPT regime, others argued that it gave India too much leeway in determining which facilities were to be safeguarded and that it effectively rewarded India for continuously refusing to accede to the Non-Proliferation Treaty.

Economic considerations

In India, the proponents of the agreement cite economic considerations as one of the topmost factors in their support of the agreement. For example, Indian scholar Rejaul Karim Laskar argues, "the most important significance of the deal for India (is) related to the contribution it will make in meeting India's energy requirements to sustain high rate of economic growth". Financially, the U.S. also expects that such a deal could spur India's economic growth and bring in $150 billion in the next decade for nuclear power plants, of which the U.S. wants a share. It is India's stated objective to increase the production of nuclear power generation from its present capacity of 4,780 MWe to 20,000 MWe by 2020. India's parliament passed The Civil Liability for Nuclear Damages bill on August 25, 2010, which allows the operator to sue the supplier in case of an accident due to technical defects in the plant. After the nuclear disaster at the Fukushima Daiichi Nuclear Power Plant in Japan, issues relating to the safety of operating nuclear power plants, compensation in the event of a radiation-leak accident, disaster clean-up costs, operator responsibility and supplier liability has once again come into the spot-light.

Nuclear technology

Dr. Siegfried S. Hecker, PhD., former Director of the Los Alamos National Laboratory, observed while testifying before a U.S. Senate Committee in 2008 that the United States might benefit from access to Indian nuclear technology: "I found that whereas sanctions slowed progress in nuclear energy, they made India self-sufficient and world leaders in fast reactor

technologies. While much of the world's approach to India has been to limit its access to nuclear technology, it may well be that today we limit ourselves by not having access to India's nuclear technology developments. Such technical views should help to advice the diplomatic efforts with India."

Because India's nuclear program was developed mostly indigenously, the country used unique techniques that other countries can learn from.

Strategic

Since the end of the Cold War, The Pentagon, along with certain U.S. ambassadors such as Robert Blackwill, has requested increased strategic ties with India and a de-hyphenization of Pakistan with India, i.e. having separate policies toward India and Pakistan rather than just an "India-Pakistan" policy. The United States also sees India as a viable counter-weight to the growing influence of China, and a potential client and job creator.

While India is self-sufficient in thorium, possessing 25% of the world's known and economically viable thorium, it possesses a meager 1% of the similarly calculated global uranium reserves. Indian support for cooperation with the U.S. centers on the issue of obtaining a steady supply of sufficient energy for the economy to grow.

Indian opposition to the pact centers on the concessions that would need to be made, as well as the likely de-prioritization of research into a thorium fuel cycle if uranium becomes highly available given the well understood utilization of uranium in a nuclear fuel cycle.

Passing of Agreement

On March 2, 2006 in New Delhi, George W. Bush and Manmohan Singh signed a Civil Nuclear Cooperation Agreement, following an initiation during the July 2005 summit in Washington between the two leaders over civilian nuclear cooperation.

Heavily endorsed by the White House, the agreement is thought to be a major victory to George W. Bush's foreign policy initiative and was described by many lawmakers as a cornerstone of the new strategic partnership between the two countries.

On August 3, 2007, both the countries released the full text of the 123 agreement. Nicholas Burns, the chief negotiator of the India-United States nuclear deal, said the U.S. has the right to terminate the deal if India tests a nuclear weapon and that no part of the agreement recognizes India as a nuclear weapons state (which would be contrary to the NPT).

Hyde Act Passage in the U.S.

On December 18, 2006 President George W. Bush signed the Hyde Act into law. The Act was passed by an overwhelming 359–68 in the United States House of Representatives on July 26 and by 85–12 in the United States Senate on November 16 in a strong show of bipartisan support.

The House version (H.R. 5682) and Senate version (S. 3709) of the bill differed due to amendments each had added before approving, but the versions were reconciled with a House vote

of 330–59 on December 8 and a Senate voice-vote on December 9 before being passed on to President G.W. Bush for final approval.

The White House had urged Congress to expedite the reconciliation process during the end-2006 lame duck session, and recommended removing certain amendments which would be deemed deal-killers by India.

In response to the language Congress used in the Act to define U.S. policy toward India, President Bush, stated "Given the Constitution's commitment to the authority of the presidency to conduct the nation's foreign affairs, the executive branch shall construe such policy statements as advisory," going on to cite sections 103 and 104 (d) (2) of the bill.

To assure Congress that its work would not be totally discarded, Bush continued by saying that the executive would give "the due weight that comity between the legislative and executive branches should require, to the extent consistent with U.S. foreign policy."

Political opposition in India

The Indo-US civilian nuclear agreement was met with stiff opposition by some political parties and activists in India. Although many mainstream political parties including the Congress(I) supported the deal along with regional parties like Dravida Munnetra Kazhagam and Rashtriya Janata Dal its realization ran into difficulties in the face of stiff political opposition in India. Also, in November 2007, former Indian Military chiefs, bureaucrats and scientists drafted a letter to

Members of Parliament expressing their support for the deal. However, opposition and criticism continued at political levels.

The Samajwadi Party (SP) which was with the Left Front in opposing the deal changed its stand after discussing with ex-president of India and scientist Dr A. P. J. Abdul Kalam. The SP then supported the government and the deal. The Indian Government survived a vote of confidence by 275–256 after the Left Front withdrew their support to the government over this dispute. Incidentally, results showed ten MPs belonging to the opposing Bharatiya Janata Party (BJP) cross-voting in the favor of the government.

As details were revealed about serious inconsistencies between what the Indian parliament was told about the deal, and the facts about the agreement that were presented by the Bush administration to the US Congress, opposition grew in India against the deal. In particular, portions of the agreement dealing with guaranteeing India a fuel supply or allowing India to maintain a strategic reserve of nuclear fuel appear to be diametrically opposed to what the Indian parliament was led to expect from the agreement: Prime Minister Manmohan Singh's statement in parliament is totally at variance with the Bush Administration's communication to the House Foreign Affairs Committee, which says India will not be allowed to stockpile such nuclear fuel stocks as to undercut American leverage to re-impose sanctions. To drive home this point, it says the 123 Agreement is not inconsistent with the Hyde Act's stipulation—the little-known 'Barack Obama Amendment' – that the supply of nuclear fuel should be "commensurate with reasonable operating requirements". The 'strategic reserve' that is crucial to India's nuclear program is, therefore, a non-starter.

Furthermore, the agreement, as a result of its compliance with the Hyde Act, contained a direct linkage between shutting down US nuclear trade with India and any potential future Indian nuclear weapons test, a point that was factually inconsistent with explicit reassurances made on this subject by Prime Minister, Manmohan Singh, during final parliamentary debate on the nuclear deal. As professor Brahma Chellaney, an expert in strategic affairs and one of the authors of the Indian Nuclear Doctrine, explained:

While the Hyde Act's bar on Indian testing is explicit, the one in the NSG waiver is implicit, yet unmistakable. The NSG waiver is overtly anchored in NSG Guidelines Paragraph 16, which deals with the consequence of "an explosion of a nuclear device". The waiver's Section 3(e) refers to this key paragraph, which allows a supplier to call for a special NSG meeting, and seek termination of cooperation, in the event of a test or any other "violation of a supplier-recipient understanding". The recently leaked Bush administration letter to Congress has cited how this Paragraph 16 rule will effectively bind India to the Hyde Act's conditions on the pain of a U.S.-sponsored cut-off of all multilateral cooperation. India will not be able to escape from the U.S.-set conditions by turning to other suppliers.

Indian parliament vote

On July 9, 2008, India formally submitted the safeguards agreement to the IAEA. This development came after the Prime Minister of India Manmohan Singh returned from the 34th G8 summit meeting in Hokkaido, Japan, where he met with U.S. President George W. Bush. On June 19, 2008, news media

reported that Indian Prime Minister Dr. Manmohan Singh threatened to resign his position if the Left Front, whose support was crucial for the ruling United Progressive Alliance to prove its majority in the Indian parliament, continued to oppose the nuclear deal and he described their stance as irrational and reactionary.

According to *The Hindu*, External Affairs Minister Pranab Mukherjee's earlier statement said "I cannot bind the government if we lose our majority," implying that United Progressive Alliance government would not put its signature on any deal with IAEA if it lost the majority in either an 'opposition-initiated no-confidence motion' or if failing to muster a vote of confidence in Indian parliament after being told to prove its majority by the president. On July 8, 2008, Prakash Karat announced that the Left Front is withdrawing its support to the government over the decision by the government to go ahead on the United States-India Peaceful Atomic Energy Cooperation Act. The left front had been a staunch advocate of not proceeding with this deal citing national interests.

On July 22, 2008 the UPA faced its first confidence vote in the Lok Sabha after the Communist Party of India (Marxist) led Left Front withdrew support over India approaching the IAEA for Indo-U.S. nuclear deal.

The UPA won the confidence vote with 275 votes to the opposition's 256, (10 members abstained from the vote) to record a 19-vote victory.

IAEA approval

The IAEA Board of Governors approved the safeguards agreement on August 1, 2008, and the 45-state Nuclear Suppliers Group next had to approve a policy allowing nuclear cooperation with India. U.S. President Bush can then make the necessary certifications and seek final approval by the U.S. Congress. There were objections from Pakistan, Iran, Ireland, Norway, Switzerland, and Austria at the IAEA meeting.

NSG waiver

On September 6, 2008 India was granted the waiver at the NSG meeting held in Vienna, Austria. The consensus was arrived at after overcoming misgivings expressed by Austria, Ireland, and New Zealand and is an unprecedented step in giving exemption to a country which has not signed the NPT and the Comprehensive Test Ban Treaty (CTBT) The Indian team who worked on the deal includes Manmohan Singh, Pranab Mukherjee, Shivshankar Menon, Shyam Saran, M. K. Narayanan, Anil Kakodkar, Ravi Grover, and DB Venkatesh Varma.

Versions of U.S. draft exemption

In August 2008 U.S. draft exemption would have granted India a waiver based on the "steps that India has taken voluntarily as a contributing partner in the non-proliferation regime". Based on these steps, and without further conditions, the draft waiver would have allowed for the transfer to India of both

trigger list and dual-use items (including technology), waiving the full-scope safeguards requirements of the NSG guidelines.

A September 2008 waiver would have recognized additional "steps that India has voluntarily taken." The waiver called for notifying the NSG of bilateral agreements and for regular consultations; however, it also would have waived the full-scope safeguards requirements of the NSG guidelines without further conditions.

The U.S. draft underwent further changes in an effort to make the language more acceptable to the NSG.

Initial support and opposition

The deal had initial support from the United States, the United Kingdom, France, Japan, Russia, and Germany. After some initial opposition, there were reports of Australia, Switzerland, and Canada expressing their support for the deal. Selig S. Harrison, a former South Asia bureau chief of *The Washington Post*, has said the deal may represent a tacit recognition of India as a nuclear weapon state, while former U.S. Undersecretary of State for Arms Control and International Security Robert Joseph says the "U.S. State Department made it very clear that we will not recognize India as a nuclear-weapon state". Norway, Austria, Brazil, and Japan all warned that their support for India at the IAEA did not mean that they would not express reservations at the NSG. New Zealand, which is a member of the NSG but not of the IAEA Board of Governors, cautioned that its support should not be taken for granted. Ireland, which launched the non-proliferation treaty process in 1958 and signed it first in 1968, doubted India's

nuclear trade agreement with the U.S. Russia, a potentially large nuclear supplier to India, expressed reservations about transferring enrichment and reprocessing technology to India. China argued the agreement constituted "a major blow to the international non-proliferation regime".

New Zealand said it would like to see a few conditions written in to the waiver: the exemption ceasing if India conducts nuclear tests, India signing the International Atomic Energy Agency's (IAEA) additional protocol, and placing limits on the scope of the technology that can be given to India and which could relate to nuclear weapons. Austria, Ireland, the Netherlands, Switzerland and Scandinavian countries proposed similar amendments. The nuclear deal was opposed by former U.S. president Jimmy Carter, who opined that the U.S. would be making "a dangerous deal with India"

After the first NSG meeting in August 2008, diplomats noted that up to 20 of the 45 NSG states tabled conditions similar to the Hyde Act for India's waiver to do business with the NSG. "There were proposals on practically every paragraph," a European diplomat said.

A group of seven NSG members suggested including some of the provisions of the U.S. Hyde Act in the final waiver. Daryll Kimball, executive director of the Washington-based Arms Control Association, said the NSG should at a minimum "make clear that nuclear trade with India shall be terminated if it resumes testing for any reason. If India cannot agree to such terms, it suggests that India is not serious about its nuclear test moratorium pledge."

Reactions following the waiver

After India was granted the waiver on September 6, the United Kingdom said that the NSG's decision would make a "significant contribution" to global energy and climate security. U.S. National Security Council spokesman Gordon Johndroe said, "this is a historic achievement that strengthens global non-proliferation principles while assisting India to meet its energy requirements in an environmentally friendly manner. The United States thanks the participating governments in the NSG for their outstanding efforts and cooperation to welcome India into the global non-proliferation community. We especially appreciate the role Germany played as chair to move this process forward." New Zealand praised the NSG consensus and said that it got the best possible deal with India. One of India's strongest allies Russia said in a statement,

"We are convinced that the exemption made for India reflects Delhi's impeccable record in the non-proliferation sphere and will guarantee the peaceful uses of nuclear exports to India." Australian Foreign Minister Stephen Smith said that the NSG granted waiver because of "India's rise as a global power" and added,

If such a request was made for another country, I don't think it would have been cleared by the NSG members." During his visit to India in September 2008, Smith said that Australia "understood and respected India's decision not to join the Non-Proliferation Treaty". German Foreign Ministry spokesman Jens Ploetner called India a "special case" and added, "Does this agreement send an approving message to Iran? No, it absolutely does not."

Initially, there were reports of the People's Republic of China analyzing the extent of the opposition against the waiver at the NSG and then revealing its position over the issue. On September 1, 2008, prominent Chinese newspaper *People's Daily* expressed its strong disapproval of the civilian agreement with India. India's National Security Advisor remarked that one of the major opponents of the waiver was China and said that he would express Indian government's displeasure over the issue. It was also revealed that China had abstained during the final voting process, indicating its non-approval of the nuclear agreement. In a statement, Chinese delegation to the NSG said the group should address the aspirations of other countries too, an implicit reference to Pakistan. There were also unconfirmed reports of India considering the cancellation of a state visit by Chinese Foreign Minister Yang Jiechi. However, External Affairs Minister Pranab Mukherjee said the Chinese Foreign Minister will be welcomed "as an honored guest". The *Times of India* noted that China's stance could have a long-term implication on Sino-Indian relations.

There were some other conflicting reports on China's stance, however. *The Hindu* reported that though China had expressed its desire to include more stern language in the final draft, they had informed India about their intention to back the agreement. In an interview to the *Hindustan Times*, Chinese Assistant Foreign Minister Hu Zhengyue said that "China understands India's needs for civil nuclear energy and related international cooperation." Chinese Foreign Minister Yang Jiechi told India's CNN-IBN, "We didn't do anything to block it [the deal]. We played a constructive role. We also adopted a positive and responsible attitude and a safeguards agreement was reached, so facts speak louder ... than some reports".

During a press conference in New Delhi, Yang added, "The policy was set much before that. When consensus was reached, China had already made it clear in a certain way that we have no problem with the [NSG] statement." Highlighting the importance of Sino-Indian relations, Yang remarked, "let us [India and China] work together to move beyond doubts to build a stronger relationship between us."

Indian reactions

Indian PM Manmohan Singh visited Washington D.C. on September 26, 2008 to celebrate the conclusion of the agreement with U.S. President George W. Bush. He also visited France to convey his appreciation for the country's stance. India's External Affairs Minister Pranab Mukherjee expressed his deep appreciation for India's allies in the NSG, especially the United States, United Kingdom, France, Russia, Germany, South Africa and Brazil for helping India achieve NSG's consensus on the nuclear deal.

Bharatiya Janata Party's Yashwant Sinha, who also formerly held the post of India's External Affairs Minister, criticized the Indian government's decision to seek NSG's consensus and remarked that "India has walked into the non-proliferation trap set by the U.S., we have given up our right to test nuclear weapons forever, it has been surrendered by the government". However, another prominent member of the same party and India's former National Security Advisor Brajesh Mishra supported the development at the NSG and said that the waiver granted made "no prohibition" on India to conduct nuclear tests in the future.

A leading advocate of the agreement was India's most eminent strategic affairs analyst K. Subrahmanyam, also known for his long and controversial championing of an Indian nuclear deterrent. He argued that the convergence of strategic interests between the two nations forced such a remarkable gesture from the US, overturning its decades-long stand on non-proliferation, and that it would be unwise on India's part to spurn such an overture. He also argued that not recognizing new geo-political realities would be even more foolhardy on the part of the Indian elite.

Former President of India and noted Indian scientist, A. P. J. Abdul Kalam, also supported the agreement and remarked that New Delhi may break its "voluntary moratorium" on further nuclear tests in "supreme national interest". However, analyst M K Bhadrakumar demurred. He said that the consensus at NSG was achieved on the "basis" of Pranab Mukherjee's commitment to India's voluntary moratorium on nuclear testing and by doing so, India has entered into a "multilateral commitment" bringing it within "the ambit of the CTBT and NPT".

The NSG consensus was welcomed by several major Indian companies. Major Indian corporations like Videocon Group, Tata Power and Jindal Power saw a US$40 billion nuclear energy market in India in the next 10–15 years. On a more optimistic note, some of India's largest and most well-respected corporations like Bharat Heavy Electricals Limited, National Thermal Power Corporation and Larsen & Toubro were eyeing a $100 billion (U.S.) business in this sector over the same time period. According to *Hindustan Times*, nuclear energy will produce 52,000 MW of electricity in India by 2020.

Other reactions over the issue

More than 150 non-proliferation activists and anti-nuclear organizations called for tightening the initial NSG agreement to prevent harming the current global non-proliferation regime. Among the steps called for were:

- ceasing cooperation if India conducts nuclear tests or withdraws from safeguards
- supplying only an amount of fuel which is commensurate with ordinary reactor operating requirements
- expressly prohibiting the transfer of enrichment, reprocessing, and heavy water production items to India
- opposing any special safeguards exemptions for India
- conditioning the waiver on India stopping fissile production and legally binding itself not to conduct nuclear tests
- not allowing India to reprocess nuclear fuel supplied by a member state in a facility that is not under permanent and unconditional IAEA safeguards
- agreeing that all bilateral nuclear cooperation agreements between an NSG member-state and India explicitly prohibit the replication or use of such technology in any unsafeguarded Indian facilities

The call said that the draft Indian nuclear "deal would be a nonproliferation disaster and a serious setback to the prospects of global nuclear disarmament" and also pushed for all world leaders who are serious about ending the arms race "to stand up and be counted."

Dr. Kaveh L. Afrasiabi, who has taught political science at Tehran University, has argued the agreement will set a new precedent for other states, adding that the agreement represents a diplomatic boon for Tehran. Ali Ashgar Soltanieh, the Iranian Deputy Director General for International and Political Affairs, has complained the agreement may undermine the credibility, integrity and universality of the Nuclear Nonproliferation Treaty. Pakistan argues the safeguards agreement "threatens to increase the chances of a nuclear arms race in the subcontinent." Pakistani Foreign Minister Shah Mahmood Qureshi has suggested his country should be considered for such an accord, and Pakistan has also said the same process "should be available as a model for other non-NPT states".

On July 19, 2010, U.S. Secretary of State Hillary Clinton countered Pakistan statements by saying that Pakistan's checkered history on nuclear proliferation "raises red flags" regarding nuclear cooperation with Pakistan. Israel is citing the Indo-U.S. civil nuclear deal as a precedent to alter Nuclear Suppliers Group (NSG) rules to construct its first nuclear power plant in the Negev desert, and is also pushing for its own trade exemptions.

Brahma Chellaney, a Professor of Strategic Studies at the New Delhi-based Centre for Policy Research, argued that the wording of the U.S. exemption sought to irrevocably tether New Delhi to the nuclear non-proliferation regime. He argued India would be brought under a wider non-proliferation net, with India being tied to compliance with the entire set of NSG rules. India would acquiesce to its unilateral test moratorium being turned into a multilateral legality. He concluded that instead

of the "full" civil nuclear cooperation that the original July 18, 2005, deal promised, India's access to civil nuclear enrichment and reprocessing technologies would be restricted through the initial NSG waiver.

Consideration by U.S. Congress

The Bush Administration told Congress in January 2008 that the United States may cease all cooperation with India if India detonates a nuclear explosive device.

The Administration further said it was not its intention to assist India in the design, construction, or operation of sensitive nuclear technologies through the transfer of dual-use items. The statements were considered sensitive in India because debate over the agreement in India could have toppled the government of Prime Minister Manmohan Singh.

The State Department had requested they remain secret even though they were not classified. Secretary of State Condoleezza Rice also previously told the House Foreign Affairs Panel in public testimony that any agreement would "have to be completely consistent with the obligations of the Hyde Act". Assistant Secretary of State for South and Central Asian Affairs Richard Boucher and the Former Assistant Secretary of State for Legislative Affairs Jeffrey Bergner also said the agreement would be in conformity with the Hyde Act.

Howard Berman, chair of the U.S. House Foreign Affairs Committee, in a letter to U.S. Secretary of State Condoleezza Rice warned that an NSG waiver "inconsistent" with the 2006 Hyde Act would "jeopardise" the Indo-U.S. nuclear deal in the

U.S. Congress. Edward J. Markey, co-chairman of the House Bipartisan Task Force on Non-proliferation, said that there needed to be clear consequences if India broke its commitments or resumed nuclear testing.

Passage in Congress

On September 28, 2008 the US House of Representatives voted 298–117 to approve the Indo-US nuclear deal. On October 1, 2008 the US Senate voted 86–13 to approve the Indo-US nuclear deal.

The Arms Control Association said the agreement fails to make clear that an Indian nuclear test would prompt the U.S. to cease nuclear trade; however,

Secretary of State Condoleezza Rice said that any nuclear test by India would result in the "most serious consequences," including automatic cut-off of U.S. cooperation as well as a number of other sanctions. After Senate approval, US President George W. Bush said the deal would "strengthen our global nuclear nonproliferation efforts, protect the environment, create jobs, and assist India in meeting its growing energy needs in a responsible manner." Then-US presidential candidates Barack Obama and John McCain, as well as then-Vice Presidential candidate Joe Biden, voted in support of the bill.

Formal signing of the deal

There was speculation the Indo-US deal would be signed on October 4, 2008 when U.S. Secretary of State Condoleezza Rice

was in India. The deal was to be inked by Indian External Affairs Minister Pranab Mukherjee and U.S. Secretary of State Condoleezza Rice. The two leaders were to sign the deal at 2 pm at the Hyderabad House in New Delhi. But Mr. Mukherjee announced that India would wait for the U.S. president to sign the 123 agreement legislation first into law and address India's concerns on fuel supply guarantees and the legal standing of the 123 agreement in the accompanying signing statement.

Ms Rice was aware of the Indian decision before she left Washington. But she was very hopeful that the deal would be signed as the U.S. State Department had said that the President's signature was not prerequisite for Rice to ink the deal. Rice had earlier said that there were still a number of administrative details to be worked out even as she insisted that the US would abide by the Hyde Act on the testing issue:

There are a lot of administrative details that have to be worked out. This (the deal) was only passed in our Congress two days ago. The President is looking forward to signing the bill, sometime, I hope, very soon, because we'll want to use it as an opportunity to thank all of the people who have been involved in this", said Rice.

In Washington, a Senate Democratic aide said that such a delay was not that unusual because legislation needed to be carefully reviewed before being sent to the White House.

US President George W. Bush signed the legislation on the Indo-US nuclear deal into law on October 8. The new law, called the **United States-India Nuclear Cooperation Approval and Non-proliferation Enhancement Act**, was signed by President Bush at a brief White House function in the presence

of the Secretary of State Condoleezza Rice, Energy Secretary Samuel Bodman, Vice-President Dick Cheney and the Indian Ambassador to the U.S. Ronen Sen besides a large gathering of other dignitaries. The final administrative aspect of the deal was completed after Secretary of State Condoleezza Rice and External Affairs Minister Pranab Mukherjee signed the bilateral instruments of the 123 Agreement in Washington on October 10 paving the way for operationalization of the deal between the two countries.

Chronology

July 18, 2005: President Bush and Prime Minister Singh first announce their intention to enter into a nuclear agreement in Washington.

March 1, 2006: Bush visits India for the first time.

March 3, 2006: Bush and Singh issue a joint statement on their growing strategic partnership, emphasising their agreement on civil nuclear cooperation.

July 26, 2006: The US House of Representatives passes the 'Henry J Hyde United States-India Peaceful Atomic Energy Cooperation Act of 2006,' which stipulates that Washington will cooperate with New Delhi on nuclear issues and exempt it from signing the Nuclear Nonproliferation Treaty.

July 28, 2006: In India, the Left parties demand threadbare discussion on the issue in Parliament.

November 16, 2006: The US Senate passes the 'United States-India Peaceful Atomic Energy Cooperation and US Additional Protocol Implementation Act' to "exempt from certain requirements of the Atomic Energy Act of 1954 United States exports of nuclear materials, equipment, and technology to India."

December 18, 2006: President Bush signs into law congressional legislation on Indian atomic energy.

July 27, 2007: Negotiations on a bilateral agreement between the United States and India conclude.

Aug 3, 2007: The text of the 'Agreement for Cooperation between the Government of the United States of America and the Government of India concerning peaceful uses of nuclear energy' (123 Agreement) is released by both governments.

Aug 13, 2007: Prime Minister Manmohan Singh makes a suo motu statement on the deal in Parliament.

Aug 17, 2007: The CPI(M) General Secretary Prakash Karat says the 'honeymoon (with government) may be over but the marriage can go on'.

Sept 4, 2007: In India, the UPA-Left committee to discuss nuclear deal set up.

Feb 25, 2008: Left parties in India say the ruling party would have to choose between the deal and its government's stability.

March 3–6, 2008: Left parties warn of 'serious consequences' if the nuclear deal is operationalised and set a deadline asking

the government to make it clear by March 15 whether it intended to proceed with the nuclear deal or drop it.

March 7–14, 2008: The CPI writes to the Prime Minister Singh, warns of withdrawal of support if government goes ahead with the deal and puts political pressure on the Manmohan Singh government not to go with the deal.

April 23, 2008: The Indian Government says it will seek the sense of the House on the 123 Agreement before it is taken up for ratification by the American Congress.

June 17, 2008: External Affairs Minister Pranab Mukherjee meets Prakash Karat, asks the Left to allow the government to go ahead with International Atomic Energy Agency (IAEA) safeguards agreement.

June 30, 2008: The Indian Prime Minister says his government prepared to face Parliament before operationalising the deal.

July 8, 2008: Left parties in India withdraw support to government.

July 9, 2008: The draft India-specific safeguards accord with the IAEA circulated to IAEA's Board of Governors for approval.

July 10, 2008: Prime Minister Manmohan Singh calls for a vote of confidence in Parliament.

July 14, 2008: The IAEA says it will meet on August 1 to consider the India-specific safeguards agreement.

July 18, 2008: Foreign Secretary Shivshankar Menon briefs the IAEA Board of Governors and some NSG countries in Vienna on the safeguards agreement.

July 22, 2008: Government is willing to look at "possible amendments" to the Atomic Energy Act to ensure that the country's strategic autonomy will never be compromised, says Prime Minister Singh.

July 22, 2008: The UPA government led by Manmohan Singh wins trust vote in the Lok Sabha in India.

July 24, 2008: India dismisses warning by Pakistan that the deal will accelerate an atomic arms race in the sub-continent.

July 24, 2008: India launches full blast lobbying among the 45-nation NSG for an exemption for nuclear commerce.

July 25, 2008: IAEA secretariat briefs member states on India-specific safeguards agreement.

Aug 1, 2008: IAEA Board of Governors adopts India- specific safeguards agreement unanimously.

Aug 21–22, 2008: The NSG meet to consider an India waiver ends inconclusively amid reservations by some countries.

Sep 4–6, 2008: The NSG meets for the second time on the issue after the US comes up with a revised draft and grants waiver to India after marathon parleys.

Sept 11, 2008: President Bush sends the text of the 123 Agreement to the US Congress for final approval.

Sept 12, 2008: US remains silent over the controversy in India triggered by President Bush's assertions that nuclear fuel supply assurances to New Delhi under the deal were only political commitments and not legally binding.

Sept 13, 2008: The State Department issues a fact sheet on the nuclear deal saying the initiative will help meet India's growing energy requirements and strengthen the non-proliferation regime by welcoming New Delhi into globally accepted nonproliferation standards and practices.

Sept 18, 2008: The Senate Foreign Relations Committee kicks off a crucial hearing on the Indo-US nuclear deal.

Sept 19, 2008: America's nuclear fuel supply assurances to India are a "political commitment" and the government cannot "legally compel" US firms to sell a "given product" to New Delhi, top officials tells Congressional panel.

Sept 21, 2008: US financial crisis diverts attention from N-deal as both the Bush Administration and the Congress are bogged down over efforts to rescue bankrupt American banks. financial crisis in the country.

Sept 26, 2008: PM Singh meets President Bush at the White House, but were not able to sign the nuclear deal as the Congress did not approve it.

Sept 27, 2008: House of Representatives approves the Indo-US nuclear deal. 298 members voted for the Bill while 117 voted against.

Oct 1, 2008: Senate approves the Indo-US civil nuclear deal with 86 votes for and 13 against.

Oct 4, 2008: Secretary of State Rice visits Delhi. India and the US unable to ink the nuclear agreement with New Delhi insisting that it would do so only after President Bush signs it into a law, an occasion when it expects certain misgivings to be cleared.

Oct 4, 2008: White House announces that President Bush will sign the legislation on the Indo-US nuclear deal into a law on October 8.

Oct 8, 2008: President Bush signs legislation to enact the landmark US-India civilian nuclear agreement.

Oct 10, 2008: The 123 Agreement between India and US is finally operationalized between the two countries after the deal is signed by External Affairs Minister Pranab Mukherjee and his counterpart Secretary of State Condoleezza Rice in Washington D C.

- Jun 8, 2016
- NPCI and Westinghouse agree to conclude contractual arrangements for 6 reactors by June 2017.

Chapter 12

Chandrayaan-1

Chandrayaan-1 was the first Indian lunarprobe under the Chandrayaan program. It was launched by the Indian Space Research Organisation in October 2008, and operated until August 2009. The mission included a lunar orbiter and an impactor. India launched the spacecraft using a PSLV-XL rocket on 22 October 2008 at 00:52 UTC from Satish Dhawan Space Centre, at Sriharikota, Andhra Pradesh. The mission was a major boost to India's space program, as India researched and developed its own technology in order to explore the Moon. The vehicle was inserted into lunar orbit on 8 November 2008.

On 14 November 2008, the Moon Impact Probe separated from the Chandrayaan orbiter at 14:36 UTC and struck the south pole in a controlled manner, making India the fourth country to place its flag insignia on the Moon. The probe hit near the crater Shackleton at 15:01 UTC, ejecting sub-surface soil that could be analysed for the presence of lunar water ice. The location of impact was named Jawahar Point.

The estimated cost for the project was ₹386 crore (US$54 million).

It was intended to survey the lunar surface over a two-year period, to produce a complete map of the chemical composition at the surface and three-dimensional topography. The polar regions are of special interest as they might contain water ice.

Among its many achievements was the discovery of widespread presence of water molecules in lunar soil.

After almost a year, the orbiter started suffering from several technical issues including failure of the star tracker and poor thermal shielding; Chandrayaan-1 stopped communicating at about 20:00 UTC on 28 August 2009, shortly after which the ISRO officially declared that the mission was over. Chandrayaan-1 operated for 312 days as opposed to the intended two years, but the mission achieved most of its scientific objectives.

On 2 July 2016, NASA used ground-based radar systems to relocate Chandrayaan-1 in its lunar orbit, more than seven years after it shut down. Repeated observations over the next three months allowed a precise determination of its orbit which varies between 150 and 270 km (93 and 168 mi) in altitude every two years.

History

Then Prime Minister of India Atal Bihari Vajpayee announced the *Chandrayaan 1* project on course in his Independence Day speech on 15 August 2003. The mission was a major boost to India's space program. The idea of an Indian scientific mission to the Moon was first raised in 1999 during a meeting of the Indian Academy of Sciences.

The Astronautical Society of India (ASI) carried forward the idea in 2000. Soon after, the Indian Space Research Organisation (ISRO) set up the National Lunar Mission Task Force which concluded that ISRO has the technical expertise to

carry out an Indian mission to the Moon. In April 2003 over 100 famous and respected Indian scientists in the fields of planetary and space sciences, Earth sciences, physics, chemistry, astronomy, astrophysics, engineering and communication sciences discussed and approved the Task Force recommendation to launch an Indian probe to the Moon. Six months later, in November, the Indian government gave approval for the mission.

Objectives

The mission had the following stated objectives:

- to design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch-vehicle
- to conduct scientific experiments using instruments on the spacecraft which would yield data:
- for the preparation of a three-dimensional atlas (with high spatial and altitude resolution of 5–10 m or 16–33 ft) of both the near and far sides of the Moon
- for chemical and mineralogical mapping of the entire lunar surface at high spatial resolution, mapping particularly the chemical elements magnesium, aluminium, silicon, calcium, iron, titanium, radon, uranium, and thorium
- to increase scientific knowledge
- to test the impact of a sub-satellite (Moon Impact Probe – MIP) on the surface of the Moon as a fore-runner for future soft-landing missions

Goals

In order to reach its objective, the mission defined these goals:

- High-resolution mineralogical and chemical imaging of the permanently shadowed north- and south-polar regions
- Searching for surface or sub-surface lunar water-ice, especially at the lunar poles
- Identification of chemicals in lunar highland rocks
- Chemical stratigraphy of the lunar crust by remote sensing of the central uplands of large lunar craters, and of the South Pole Aitken Region (SPAR), an expected site of interior material
- Mapping the height variation of features of the lunar surface
- Observation of X-ray spectrum greater than 10 keV and stereographic coverage of most of the Moon's surface with 5 m (16 ft) resolution
- Providing new insights in understanding the Moon's origin and evolution

Specifications

- Mass
- 1,380 kg (3,042 lb) at launch, 675 kg (1,488 lb) at lunar orbit, and 523 kg (1,153 lb) after releasing the impactor.
- Dimensions
- Cuboid in shape of approximately 1.5 m (4.9 ft)
- Communications

- X band, 0.7 m (2.3 ft) diameter dual gimballed parabolic antenna for payload data transmission. The Telemetry, Tracking & Command (TTC) communication operates in S band frequency.
- Power
- The spacecraft was mainly powered by its solar array, which included one solar panel covering a total area of 2.15 × 1.8 m (7.1 × 5.9 ft) generating 750 W of peak power, which was stored in a 36 A·h lithium-ion battery for use during eclipses.
- Propulsion
- The spacecraft used a bipropellant integrated propulsion system to reach lunar orbit as well as orbit and altitude maintenance while orbiting the Moon. The power plant consisted of one 440 N engine and eight 22 N thrusters. Fuel and oxidiser were stored in two tanks of 390 litres (100 US gal) each.
- Navigation and control
- The craft was 3-axis stabilised with two star sensors, gyros and four reaction wheels. The craft carried dual redundant bus management units for attitude control, sensor processing, antenna orientation, etc.

Payload

The scientific payload had a mass of 90 kg (198 lb) and contained five Indian instruments and six instruments from other countries.

Indian instruments

- **TMC** or the **Terrain Mapping Camera** is a CMOS camera with 5 m (16 ft) resolution and a 40 km (25 mi) swath in the panchromatic band and was used to produce a high-resolution map of the Moon. The aim of this instrument was to completely map the topography of the Moon. The camera works in the visible region of the electromagnetic spectrum and captures black and white stereo images. When used in conjunction with data from Lunar Laser Ranging Instrument (LLRI), it can help in better understanding of the lunar gravitational field as well. TMC was built by the ISRO's Space Applications Centre (SAC) at Ahmedabad. The TMC was tested on 29 October 2008 through a set of commands issued from ISTRAC.
- **HySI** or **Hyper Spectral Imager** is a CMOS camera, performed mineralogical mapping in the 400–900 nm band with a spectral resolution of 15 nm and a spatial resolution of 80 m (260 ft).
- **LLRI** or **Lunar Laser Ranging Instrument** determines the height of the surface topography by sending pulses of infrared laser light towards the lunar surface and detecting the reflected portion of that light. It operated continuously and collected 10 measurements per second on both the day and night sides of the Moon. LLRI was developed by Laboratory for Electro Optics Systems of ISRO, Bangalore. It was tested on 16 November 2008.
- **HEX** is a **High Energy aj/gamma x-ray spectrometer** for 30–200 keV measurements with

ground resolution of 40 km (25 mi), the HEX measured U, Th, Pb, Rn degassing, and other radioactive elements.

- **MIP** or the **Moon Impact Probe** developed by the ISRO, is an impact probe which consisted of a C-band Radar altimeter for measurement of altitude of the probe, a video imaging system for acquiring images of the lunar surface and a mass spectrometer for measuring the constituents of the lunar atmosphere. It was ejected at 14:30 UTC on 14 November 2008. As planned, the Moon Impact Probe impacted the lunar south pole at 15:01 UTC on 14 November 2008. It carried with it a picture of the Indian flag. India is now the fourth nation to place a flag on the Moon after the Soviet Union, United States and Japan.

Instruments from other countries

- **C1XS** or **X-ray fluorescence spectrometer** covering 1–10 keV, mapped the abundance of Mg, Al, Si, Ca, Ti, and Fe at the surface with a ground resolution of 25 km (16 mi), and monitored solar flux. This payload results from collaboration between Rutherford Appleton laboratory, U.K, ESA and ISRO. It was activated on 23 November 2008.
- **SARA**, the **Sub-keV Atom Reflecting Analyser** from the ESA mapped mineral composition using low energy neutral atoms emitted from the surface.
- **M**, the **Moon Mineralogy Mapper** from Brown University and JPL (funded by NASA) is an imaging

spectrometer designed to map the surface mineral composition. It was activated on 17 December 2008.

- **SIR-2**, a near infrared spectrometer from ESA, built at the Max Planck Institute for Solar System Research, Polish Academy of Science and University of Bergen, also mapped the mineral composition using an infrared grating spectrometer. The instrument is similar to that of the Smart-1 SIR. It was activated on 19 November 2008 and scientific observations were started on 20 November 2008.
- **Mini-SAR**, designed, built and tested for NASA by a large team that includes the Naval Air Warfare Center, Johns Hopkins University Applied Physics Laboratory, Sandia National Laboratories, Raytheon and Northrop Grumman, with outer support from ISRO. Mini-SAR is the active Synthetic Aperture Radar system to search for lunar polar ice, water-ice. The instrument transmitted right polarised radiation with a frequency of 2.5 GHz and monitored scattered left and right polarised radiation. The Fresnel reflectivity and the circular polarisation ratio (CPR) are the key parameters deduced from these measurements. Ice shows the Coherent Backscatter Opposition Effect which results in an enhancement of reflections and CPR, so that water content of the Moon's polar regions can be estimated.
- **RADOM-7**, **Radiation Dose Monitor Experiment** from the Bulgarian Academy of Sciences mapped the radiation environment around the Moon. It was tested on 16 November 2008.

Mission timeline

During the tenure of Prime Minister Manmohan Singh, the Chandrayaan project got a boost and finally Chandrayaan-1 was launched on 22 October 2008 at 00:52 UTC from Satish Dhawan Space Centre using the ISRO's 44.4-metre (146 ft) tall, four-stage PSLV C11 launch vehicle. Chandrayaan-1 was sent to the Moon in a series of orbit-increasing manoeuvres around the Earth over a period of 21 days as opposed to launching the craft on a direct trajectory to the Moon. At launch the spacecraft was inserted into geostationary transfer orbit (GTO) with an apogee of 22,860 km (14,200 mi) and a perigee of 255 km (158 mi). The apogee was increased with a series of five orbit burns conducted over a period of 13 days after launch.

For the duration of the mission, ISRO's telemetry, tracking and command network (ISTRAC) at Peenya in Bangalore, tracked and controlled Chandrayaan-1. Scientists from India, Europe, and the U.S. conducted a high-level review of Chandrayaan-1 on 29 January 2009 after the spacecraft completed its first 100 days in space.

Earth orbit burns

- First orbit burn

The first orbit-raising manoeuvre of Chandrayaan-1 spacecraft was performed at 03:30 UTC on 23 October 2008 when the spacecraft's 440 Newton liquid engine was fired for about 18 minutes by commanding the spacecraft from Spacecraft Control Centre (SCC) at ISRO Telemetry, Tracking and Command Network (ISTRAC) at Peenya, Bangalore. With this

Chandrayaan-1's apogee was raised to 37,900 km (23,500 mi), and its perigee to 305 km (190 mi). In this orbit, Chandrayaan-1 spacecraft took about 11 hours to go around the Earth once.

- Second orbit burn

The second orbit-raising manoeuvre of Chandrayaan-1 spacecraft was carried out on 25 October 2008 at 00:18 UTC when the spacecraft's engine was fired for about 16 minutes, raising its apogee to 74,715 km (46,426 mi), and its perigee to 336 km (209 mi), thus completing 20 percent of its journey. In this orbit,

Chandrayaan-1 spacecraft took about twenty-five and a half hours to go round the Earth once. This is the first time an Indian spacecraft has gone beyond the 36,000 km (22,000 mi) high geostationary orbit and reached an altitude more than twice that height.

- Third orbit burn

The third orbit raising manoeuvre was initiated on 26 October 2008 at 01:38 UTC when the spacecraft's engine was fired for about nine and a half minutes. With this its apogee was raised to 164,600 km (102,300 mi), and the perigee to 348 km (216 mi). In this orbit, Chandrayaan-1 took about 73 hours to go around the Earth once.

- Fourth orbit burn

The fourth orbit-raising manoeuvre took place on 29 October 2008 at 02:08 UTC when the spacecraft's engine was fired for about three minutes, raising its apogee to 267,000 km

(166,000 mi) and the perigee to 465 km (289 mi). This extended its orbit to a distance more than half the way to the Moon. In this orbit, the spacecraft took about six days to go around the Earth once.

- Final orbit burn

The fifth and final orbit raising manoeuvre was carried out on 3 November 2008 at 23:26 UTC when the spacecraft's engine was fired for about two and a half minutes resulting in Chandrayaan-1 entering the Lunar Transfer Trajectory with an apogee of about 380,000 km (240,000 mi).

Lunar orbit insertion

Chandrayaan-1 completed the lunar orbit insertion operation on 8 November 2008 at 11:21 UTC. This manoeuvre involved firing of the liquid engine for 817 seconds (about thirteen and half minutes) when the spacecraft passed within 500 km (310 mi) from the Moon. The satellite was placed in an elliptical orbit that passed over the polar regions of the Moon, with 7,502 km (4,662 mi) aposelene and 504 km (313 mi) periselene. The orbital period was estimated to be around 11 hours. With the successful completion of this operation, India became the fifth nation to put a vehicle in lunar orbit.

- First orbit reduction

First Lunar Orbit Reduction Manoeuvre of Chandrayaan-1 was carried out on 9 November 2008 at 14:33 UTC. During this, the engine of the spacecraft was fired for about 57 seconds.

This reduced the periselene to 200 km (124 mi) while aposelene remained unchanged at 7,502 km. In this elliptical orbit, Chandrayaan-1 took about ten and a half hours to circle the Moon once.

- Second orbit reduction

This manoeuvre was carried out on 10 November 2008 at 16:28 UTC, resulting in steep decrease in Chandrayaan-1's aposelene to 255 km (158 mi) and its periselene to 187 km (116 mi), During this manoeuvre, the engine was fired for about 866 seconds (about fourteen and a half minutes). Chandrayaan-1 took two hours and 16 minutes to go around the Moon once in this orbit.

- Third orbit reduction

Third Lunar Orbit Reduction was carried out by firing the onboard engine for 31 seconds on 11 November 2008 at 13:00 UTC.

This reduced the periselene to 101 km (63 mi), while the aposelene remained constant at 255 km. In this orbit Chandrayaan-1 took two hours and 9 minutes to go around the Moon once.

- Final orbit

Chandrayaan-1 spacecraft was placed into a mission-specific lunar polar orbit of 100 km (62 mi) above the lunar surface on 12 November 2008. In the final orbit reduction manoeuvre, Chandrayaan-1's aposelene and periselene were both reduced to 100 km. In this orbit, Chandrayaan-1 takes about two hours

to go around the Moon once. Two of the 11 payloads—the Terrain Mapping Camera (TMC) and the Radiation Dose Monitor (RADOM)—were switched on. The TMC acquired images of both the Earth and the Moon.

Impact of the MIP on the lunar surface

The Moon Impact Probe (MIP) crash-landed on the lunar surface on 14 November 2008, 15:01 UTC near the crater Shackleton at the south pole. The MIP was one of eleven scientific instruments (payloads) on board Chandrayaan-1.

The MIP separated from Chandrayaan at 100 km from lunar surface and began its nosedive at 14:36 UTC. going into free fall for thirty minutes. As it fell, it kept sending information back to the mother satellite which, in turn, beamed the information back to Earth. The altimeter then also began recording measurements to prepare for a rover to land on the lunar surface during a second Moon mission.

Following the deployment of the MIP, the other scientific instruments were turned on, starting the next phase of the mission.

After scientific analyses of the received data from the MIP, the Indian Space Research Organisation confirmed the presence of water in the lunar soil and published the finding in a press conference addressed by its then Chairman G. Madhavan Nair.

Rise of spacecraft's temperature

ISRO had reported on 25 November 2008 that Chandrayaan-1's temperature had risen above normal to 50 °C (122 °F),

Scientists said that it was caused by higher than expected temperatures in lunar orbit. The temperature was brought down by about 10 °C (18 °F) by rotating the spacecraft about 20 degrees and switching off some of the instruments. Subsequently, ISRO reported on 27 November 2008 that the spacecraft was operating under normal temperature conditions.

In subsequent reports ISRO says, since the spacecraft was still recording higher than normal temperatures, it would be running only one instrument at a time until January 2009 when lunar orbital temperature conditions are said to stabilize. It was initially thought that the spacecraft was experiencing high temperature because of radiation from the Sun and infrared radiation reflected by the Moon.

However the rise in spacecraft temperature was later attributed to a batch of DC-DC converters with poor thermal regulation.

Mapping of minerals

The mineral content on the lunar surface was mapped with the Moon Mineralogy Mapper (M), a NASA instrument on board the orbiter. The presence of iron was reiterated and changes in rock and mineral composition have been identified. The Oriental Basin region of the Moon was mapped, and it indicates abundance of iron-bearing minerals such as pyroxene.

In 2018 it was announced that M infrared data had been re-analyzed to confirm the existence of water across wide expanses of the Moon's polar regions.

Mapping of Apollo landing sites

ISRO announced in January 2009 the completion of the mapping of the Apollo Moon missions landing sites by the orbiter, using multiple payloads. Six of the sites have been mapped including landing sites of Apollo 15 and Apollo 17.

Image acquisition

The craft completed 3,000 orbits acquiring 70,000 images of the lunar surface, which is quite a record compared to the lunar flights of other nations. ISRO officials estimated that if more than 40,000 images have been transmitted by Chandrayaan's cameras in 75 days, it worked out to nearly 535 images being sent daily.

They were first transmitted to Indian Deep Space Network at Byalalu near Bangalore, from where they were flashed to ISRO's Telemetry Tracking And Command Network (ISTRAC) at Bangalore.

Some of these images have a resolution of down to 5 metres (16 ft), providing a sharp and clear picture of the Moon's surface, while many images sent by some of the other missions had only a 100-metre resolution. For comparison, the Lunar Reconnaissance Orbiter Camera has a 0.5 meter resolution.

On 26 November, the indigenous Terrain Mapping Camera, which was first activated on 29 October 2008, acquired images of peaks and craters. This came as a surprise to ISRO officials because the Moon consists mostly of craters.

Detection of X-Ray signals

The X-ray signatures of aluminium, magnesium and silicon were picked up by the C1XS X-ray camera. The signals were picked up during a solar flare that caused an X-ray fluorescence phenomenon. The flare that caused the fluorescence was within the lowest C1XS sensitivity range.

Full Earth image

On 25 March 2009 Chandrayaan beamed back its first images of the Earth in its entirety. These images were taken with the TMC. Previous imaging was done on only one part of the Earth. The new images show Asia, parts of Africa and Australia with India being in the center.

Orbit raised to 200 km

After the completion of all the major mission objectives, the orbit of Chandrayaan-1 spacecraft, which had been at a height of 100 km (62 mi) from the lunar surface since November 2008, was raised to 200 km (124 mi).

The orbit raising manoeuvres were carried out between 03:30 and 04:30 UTC on 19 May 2009. The spacecraft in this higher altitude enabled further studies on orbit perturbations, gravitational field variation of the Moon and also enabled imaging lunar surface with a wider swath. It was later revealed that the true reason for the orbit change was that it was an attempt to keep the temperature of the probe down. It was "...assumed that the temperature [of the spacecraft subsystems] at 100 km above the Moon's surface would be

around 75 degrees Celsius. However, it was more than 75 degrees and problems started to surface. We had to raise the orbit to 200 km."

Attitude sensor failure

The star tracker, a device used for pointing attitude determination (orientation), failed in orbit after nine months of operation. Afterward, the orientation of Chandrayaan was determined using a back-up procedure using a two-axis Sun sensor and taking a bearing from an Earth station. This was used to update three axis gyroscopes which enabled spacecraft operations. The second failure, detected on 16 May, was attributed to excessive radiation from the Sun.

Radar scans

On 21 August 2009 Chandrayaan-1 along with the Lunar Reconnaissance Orbiter attempted to perform a bistatic radar experiment using their Mini-SAR radars to detect the presence of water ice on the lunar surface. The attempt was a failure; it turned out the Chandrayaan-1 radar was not pointed at the Moon during the experiment.

The Mini-SAR has imaged many of the permanently shadowed regions that exist at both poles of the Moon. In March 2010, it was reported that the Mini-SAR on board the Chandrayaan-1 had discovered more than 40 permanently darkened craters near the Moon's north pole which are hypothesized to contain an estimated 600 million metric tonnes of water-ice. The radar's high CPR is not uniquely diagnostic of either roughness or ice; the science team must take into account the

environment of the occurrences of high CPR signal to interpret its cause. The ice must be relatively pure and at least a couple of meters thick to give this signature. The estimated amount of water ice potentially present is comparable to the quantity estimated from the previous mission of Lunar Prospector's neutron data.

Although the results are consistent with recent findings of other NASA instruments onboard Chandrayaan-1 (the Moon Mineralogy Mapper (MP3) discovered water molecules in the Moon's polar regions, while water vapour was detected by NASA's Lunar Crater Observation and Sensing Satellite, or LCROSS) this observation is not consistent with the presence of thick deposits of nearly pure water ice within a few meters of the lunar surface, but it does not rule out the presence of small (<~10 cm), discrete pieces of ice mixed in with the regolith.

End of the mission

The mission was launched on 22 October 2008 and expected to operate for two years. However, around 20:00 UTC on 28 August 2009 communication with the spacecraft was suddenly lost. The probe had operated for 312 days. The craft had been expected to remain in orbit for approximately another 1000 days and to crash into the lunar surface in late 2012, although in 2016 it was found to still be in orbit.

A member of the science advisory board of Chandrayaan-1 said that it is difficult to ascertain reasons for the loss of contact. ISRO Chairman Madhavan Nair said that due to very high radiation, power-supply units controlling both the computer

systems on board failed, snapping the communication connectivity. However, information released later showed that the power supply supplied by MDI failed due to overheating.

Although the mission was less than 10 months in duration, and less than half the intended two years in length, a review by scientists termed the mission successful, as it had completed 95% of its primary objectives.

Results

Chandrayaan's NASA Instrument Moon Mineralogy Mapper has confirmed the magma ocean hypothesis, meaning that the Moon was once completely molten.

The terrain mapping camera on board Chandrayaan-1, besides producing more than 70,000 three dimensional images, has recorded images of the landing site of U.S. spacecraft Apollo 15.

TMC and HySI payloads of ISRO have covered about 70% of the lunar surface, while M covered more than 95% of the same and SIR-2 has provided high-resolution spectral data on the mineralogy of the Moon.

Indian Space Research Organisation said interesting data on lunar polar areas was provided by Lunar Laser Ranging Instrument (LLRI) and High Energy X-ray Spectrometer (HEX) of ISRO as well as Miniature Synthetic Aperture Radar (Mini-SAR) of the USA.

LLRI covered both the lunar poles and additional lunar regions of interest, HEX made about 200 orbits over the lunar poles

and Mini-SAR provided complete coverage of both North and South Polar Regions of the Moon. Another ESA payload – Chandrayaan-1 imaging X-ray Spectrometer (C1XS) – detected more than two dozen weak solar flares during the mission duration. The Bulgarian payload called Radiation Dose Monitor (RADOM) was activated on the day of the launch itself and worked until the mission's end.

ISRO said scientists from India and participating agencies expressed satisfaction on the performance of Chandrayaan-1 mission as well as the high quality of data sent by the spacecraft.

They have started formulating science plans based on the data sets obtained from the mission. It is expected that in the next few months, interesting results about lunar topography, mineral and chemical contents of the Moon and related aspects are expected to be published.

The Chandrayaan-1 payload has enabled scientists to study the interaction between the solar wind and a planetary body like the Moon without a magnetic field.

In its 10-month orbit around the Moon, Chandrayaan-1's X-ray Spectrometer (C1XS) detected titanium, confirmed the presence of calcium, and gathered the most accurate measurements yet of magnesium, aluminium and iron on the lunar surface.

Lunar water discovery

On 18 November 2008, the Moon Impact Probe was released from Chandrayaan-1 at a height of 100 km (62 mi). During its 25-minute descent, Chandra's Altitudinal Composition

Explorer (CHACE) recorded evidence of water in 650 mass spectra readings gathered during this time. On 24 September 2009 *Science* journal reported that the Nasa Instrument Moon Mineralogy Mapper (M) on Chandrayaan-1 had detected water ice on the Moon.

But, on 25 September 2009, ISRO announced that the MIP, another instrument on board Chandrayaan-1, had discovered water on the Moon just before impact and had discovered it 3 months before NASA's M. The announcement of this discovery was not made until NASA confirmed it.

M detected absorption features near 2.8–3.0 μm on the surface of the Moon. For silicate bodies, such features are typically attributed to hydroxyl- and/or water-bearing materials. On the Moon, the feature is seen as a widely distributed absorption that appears strongest at cooler high latitudes and at several fresh feldspathic craters. The general lack of correlation of this feature in sunlit M data with neutron spectrometer H abundance data suggests that the formation and retention of OH and H_2O is an ongoing surficial process. OH/H_2O production processes may feed polar cold traps and make the lunar regolith a candidate source of volatiles for human exploration.

The Moon Mineralogy Mapper (M), an imaging spectrometer, was one of the 11 instruments on board Chandrayaan-I that came to a premature end on 28 August 2009. M was aimed at providing the first mineral map of the entire lunar surface. M data were reanalyzed years later and revealed "the most definitive proof to date" of the presence of water in shaded regions of craters near the Moon's north and south poles.

Lunar scientists had discussed the possibility of water repositories for decades. They are now increasingly "confident that the decades-long debate is over" a report says. "The Moon, in fact, has water in all sorts of places; not just locked up in minerals, but scattered throughout the broken-up surface, and, potentially, in blocks or sheets of ice at depth." The results from the Chandrayaan mission are also "offering a wide array of watery signals."

Lunar water production

According to European Space Agency (ESA) scientists, the lunar regolith (a loose collection of irregular dust grains making up the Moon's surface) absorbs hydrogen nuclei from solar winds. Interaction between the hydrogen nuclei and oxygen present in the dust grains is expected to produce hydroxyl (HO^-) and water (H_2O).

The SARA (Sub keV Atom Reflecting Analyser) instrument developed by ESA and the Indian Space Research Organisation was designed and used to study the Moon's surface composition and solar-wind/surface interactions. SARA's results highlight a mystery: not every hydrogen nucleus is absorbed. One out of every five rebounds into space, combining to form an atom of hydrogen. Hydrogen shoots off at speeds of around 200 kilometres per second (120 mi/s) and escapes without being deflected by the Moon's weak gravity. This knowledge provides timely advice for scientists who are readying ESA's *BepiColombo* mission to Mercury, as that spacecraft will carry two instruments similar to SARA.

Lunar caves

Chandrayaan-1 imaged a lunar rille, formed by an ancient lunar lava flow, with an uncollapsed segment indicating the presence of a lunar lava tube, a type of large cave below the lunar surface. The tunnel, which was discovered near the lunar equator, is an empty volcanic tube, measuring about 2 km (1.2 mi) in length and 360 m (1,180 ft) in width. According to A. S. Arya, scientist SF of Ahmedabad-based Space Application Centre (SAC), this could be a potential site for human settlement on the Moon. Earlier, Japanese Lunar orbiter SELENE (Kaguya) also recorded evidence for other caves on the Moon.

Tectonism

Data from the microwave sensor (Mini-SAR) of Chandrayaan-1 processed using the image analysis software ENVI, has revealed a good amount of past tectonic activity on the lunar surface. The researchers think that the faults and fractures discovered could be features of past interior tectonic activity coupled with meteorite impacts.

Awards

- The American Institute of Aeronautics and Astronautics (AIAA) has selected ISRO's Chandrayaan-1 mission as one of the recipients of its annual AIAA SPACE 2009 awards, which recognises key contributions to space science and technology.

- The International Lunar Exploration Working Group awarded the Chandrayaan-1 team the International Co-operation Award in 2008 for accommodation and tests of the most international lunar payload ever (from 20 countries, including India, the European Space Agency of 17 countries, USA, and Bulgaria).
- US-based National Space Society awarded ISRO the 2009 Space Pioneer Award in the science and engineering category, for the Chandrayaan-1 mission.

Public release of data

Data gathered by Chandrayaan-I was made available to the public by the end of the year 2010. The data was split into two seasons with the first season going public by the end of 2010 and the second going public by the mid of 2011. The data contained pictures of the Moon and also data of chemical and mineral mapping of the lunar surface.

Follow-up missions

Chandrayaan-2 is a follow-up mission which was launched on 22 July 2019. The mission includes a lunar orbiter, a lander named *Vikram* and a robotic lunar rover named *Pragyan*. The rover was designed to move on six wheels on the lunar surface, do on-site chemical analysis and send the data to the Earth via the Chandrayaan-2 orbiter, which will be orbiting the Moon. The third mission, called Chandrayaan-3 is tentatively scheduled for 2024.

Lunar outpost

Chandrayaan's imagery will be used to identify regions of interest that will be explored in detail by the NASA Lunar Reconnaissance Orbiter. The interest lies in identifying lunar water on the surface that can be exploited in setting up a future lunar outpost. The Mini-SAR, one of the U.S. payloads on Chandrayaan, was used to determine the presence of water ice.

Chapter 13

Chandrayan-1: Team

G. Madhavan Nair

G. Madhavan Nair (born 31 October 1943) is an Indian space scientist and a former Chairman of the Indian Space Research Organisation, and Secretary to the Department of Space, Government of India. He has also been the Chairman of the Space Commission and Chairman of the Governing Body of the Antrix Corporation, Bangalore. He was Chairman of the Board of Governors of the Indian Institute of Technology Patna until he stepped down due to his involvement in a controversial deal relating to sale of radio spectrum bandwidth involving Antrix. He was subsequently barred from holding any government positions.

Nair was awarded the Padma Vibhushan, India's second highest civilian honour, on 26 January 2009.

Early life

Nair was born in Kulasekharam, Travancore State, (now in Kanyakumari district, Tamil Nadu), India. He graduated with a B.Sc. in Engineering (1966) from College of Engineering, Trivandrum, of the University of Kerala with specialization in Electronics & Communication Engineering. After his graduation, Nair attended a training program at the Bhabha Atomic Research Center (BARC) Training School, Mumbai.

Career

Nair is a leading technologist in the field of rocket systems and has made significant contribution to the development of multi-stage satellite launch vehicles, achieving self-reliance in independent access to space using indigenous technologies. Nair and his team have advanced their work in the face of several challenges in the regime of technology denials by adopting several innovations and novel techniques to realise world class launch vehicle systems. India today has a pride of place amongst the space-faring nations in launch vehicle technology. Specifically, as Project Director, he led the development of Polar Satellite Launch Vehicle (PSLV) which has since become the workhorse for launching mainly Indian remote sensing satellites.

As Director of ISRO's largest R & D Centre, the Vikram Sarabhai Space Centre, he also saw India's Geo-synchronous Satellite Launch Vehicle (GSLV) successfully come to fruition. Further, as Director of the Liquid Propulsion Systems Centre of ISRO, he played a central role in the design and development of the crucial cryogenic engine for GSLV.

As Chairman of ISRO

As the Chairman of Indian Space Research Organization, Nair is entrusted with the responsibility for the development of space technology and its application to national development. During his tenure as Chairman, ISRO/Secretary, DOS, twenty seven successful missions were accomplished i.e., INSAT-3E, Resourcesat-1, Edusat, Cartosat-1, Hamsat-1, INSAT-4A,

PSLV-C5, GSLV-F01, PSLV-C6, Cartosat-2, INSAT-4B, SRE-1, PSLV-C7, PSLV-C8, GSLV-F04, INSAT-4CR, PSLV-C10, Cartosat-2A, IMS-1, PSLV-C9, Chandrayaan-1, PSLV-C11, PSLV-C12, RISAT-2, ANUSAT, PSLV-C14 and Ocensat-2 . He has taken initiatives towards development of futuristic technologies to enhance the space systems capabilities as well as to reduce the cost of access to space. Nair has given major thrust for evolving application programmes such as tele-education and telemedicine for meeting the needs of society at large. As Chairman Space Commission,

Nair is responsible for chalking out the future plan for space research in the country. Major thrust are in scientific exploration of outer space using the Astrosat and Chandrayaan (moon) missions apart from implementing schemes for telemedicine, tele-education and disaster management support systems. He is also providing guidance and leadership in undertaking new technology developments related to launch vehicle, spacecraft for communication, remote sensing and applications programmes to meet societal needs.

In the international arena, Nair has led the Indian delegations for bilateral cooperation and negotiations with many Space Agencies and Countries, specially with France, Russia, Brazil, Israel, etc., and has been instrumental in working out mutually beneficial international cooperative agreements. Nair has led the Indian delegation to the S&T Sub-Committee of United Nations Committee on Peaceful Uses of Outer Space (UN-COPUOS) since 1998.

His main focus has always been to achieve self-reliance in the high technology areas and to bring the benefits of space

technology to India's development, specially targeting the needs of the rural and poor sections of society.

Establishment of the Indian Institute of Space Science and Technology

G. Madhavan Nair initiated and implemented the establishment of Indian Institute of Space Science and Technology in Thiruvananthapuram. There were some objections and impediments in its establishment.

Controversies in S-Band Devas Scam

The contract signed between Antrix Corporation and Devas Multimedia Private Limited on 28 January 2005 during Nair's tenure as chairman of ISRO and secretary of Department of Space, was controversial. As a consequence of it, on 25 January 2012 he was barred from holding any government jobs. As of August 2017, he was still awaiting trial.

Additional responsibilities

Nair has promoted space science and technology for the socio-economic benefit of India, he is also the Chairman of the Governing Body of the Antrix Corporation, Bangalore. He was chairman of the National Remote Sensing Agency until it became National Remote Sensing Centre.

He was president of Astronautical Society of India in 2004 and of the Aeronautical Society of India in 2005, as well as vice-president of the Scientific Activities Committee of the

International Academy of Astronautics (IAA) from 2006. In August 2009, he was elected president of the IAA. He is the only Indian and the first non-American to IAA.

Nair was General President of the 97th Indian Science Congress 2009-2010 and first chairman of the board of governors of Indian Institute of Technology Patna.

Awards

Nair has won several awards such as National Aeronautical Award, FIE Foundation's Award, Shri Om Prakash Bhasin Award, Swadeshi Sastra Puraskar Award, Vikram Sarabhai Memorial Gold Medal of the Indian Science Congress Association, Dr.Yelavarthy Nayudamma Memorial Award-2004, HK Firodia Award-2005, Fifth "Shri Balvantbhai Parekh Award",

Lokmanya Tilak Award from Tilak Smarak Trust, "Sree Chithira Thirunal Award" from Sree Chithira Thirunal Trust, "MP Birla Memorial Award 2009", "Bhu Ratna Award", "Mohamed Abdu Rahiman Sahib National Award", "AV Rama Rao Technology Award", "Chanakya Award" etc., He has also received Gold Medal from the Prime Minister at the 94th Indian Science Congress at Chidambaram in 2007. He received M M Chugani award for 2006, conferred by Indian Physics Association at IIT Mumbai during March 2008. He was also conferred with "Raja Rammohan Puraskar" award on the 236th birth anniversary of Raja Rammohan Roy at Kolkata during May 2008.

The Government of India awarded Nair the Padma Bhushan in 1998 and the Padma Vibhushan in 2009.

Nair has received numerous honorary degrees, including:

- D.Philosophy: Punjab Technical University, Jalandhar (2003).
- D.Sc.: Sri Venkateswara University, Tirupati (2004), Indian Institute of Technology Delhi (2004), Rani Durgavati Vishwavidyalaya, Jabalpur (2005), Indira Gandhi National Open University, Delhi (2005), Rani Durgavati Vishwavidyalaya, Jabalpur (2005), Cochin University of Science and Technology, Kochi (2006), Rajiv Gandhi Technical University, Bhopal (2007), University of Kerala, Kerala (2007), SRM Institute of Science and Technology, Chennai (2008), Pandit Ravishankar Shukla University, Raipur (2009), Karnatak University, Dharwad (2009), Indian Institute of Technology Bombay (2009), Indian Institute of Technology Kharagpur (2009)
- Honorary Doctorate by Suresh Gyan Vihar University, Jaipur (2014)
- Honorary Doctorate by Amity University, Gurgaon 2015

Fellowships/Memberships

- Fellow, Indian National Academy of Engineering.
- Fellow, Astronautical Society of India.
- Fellow, National Academy of Sciences, India.
- Honorary Fellow, Indian Society for Non-Destruction Testing (ISNT).
- Member, System Society of India.
- Member, Working Committee of the Current Science Association 2004-06.

- Member, International Academy of Astronautics (2004).
- Senior Associate, National Institute of Advanced Studies (2004–2007).
- President, Intersputnik Board (2005)
- Honorary Fellow of The Aeronautical Society of India (2007).
- Honorary Life fellow Institution of Engineers (India) Kolkata (2008)
- Chairman, Research Council of National Aerospace Laboratories (April 2007 to March 2010).
- President of the International Academy of Astronautics (2009)

Thekkethil Kochandy Alex

Thekkethil Kochandy Alex is an Indian space scientist. He was the director of the ISRO Satellite Centre (ISAC) of Indian Space Research Organisation (ISRO) (2008–2012) and Member, Space Commission.

He specialized in electro-optic systems and satellite technology. Starting with the first Indian satellite Aryabhata he has been responsible for the sensor systems in all the Indian satellites.

Under his leadership the Laboratory for Electro Optics Systems (LEOS) was established in 1993 and from the inception he was its director till 2008. He was conferred "Dr. Vikram Sarabhai Distinguished Professorship" in 2011.

Education

Dr. Alex from Kerala studied at the SRVLP school, Azhoor, Pathanamthitta and his high school studies were at the Catholicate High School. This was followed by the pre-university course at the Catholicate College Pathanamthitta,kerala. He studied at the T.K.M. College of Engineering, Kollam from 1964 to 1969. He received his bachelor's degree in Electrical Engineering from the Kerala University (Gold Medallist), Masters from IIT Madras and Doctorate from IISc Bangalore in Aerospace Engineering.

Contributions to ISRO/India

Alex has contributed to Indian Space Research Organisation (ISRO) by establishing the Laboratory for Electro-Optics Systems in Bangalore. Alex was the project director of the remote sensing experiment on board the Indo-soviet manned mission in which the first Indian astronaut, Rakesh Sharma, squadron leader, flew aboard Soyuz T-11, launched on 3 April 1984. He contributed to India to the first Indian Moon mission, *Chandrayaan-1* in 2008. He provided guidance to the inter-planetary mission, Mars Orbiter mission, *Mangalyaan*.

Awards and recognition

Alex was awarded the Padma Shri in 2007, and the Distinguished Achievement Award of ISRO in 1976 for his contributions for the first Indian satellite. Other awards received include the IMDA award for the development of Infrared sensors and the Hari Om Ashram Vikram Sarbhai

award (1987). He received the Aryabhata Award(2015) of the Astronautical Society of India. He is a fellow of the Indian National Academy of Engineering (INAE), National Academy of Science, India (NASI) and the Institution of Electronics and Telecommunication Engineering, India (IETE) and a life member of ASI and Instrument Society of India. He is a fellow of the Optical Society of India and he was its President (2010–11).

Mylswamy Annadurai

Mylswamy Annadurai, popularly known as Moon Man of India, is an Indian scientist working as vice president for Tamil Nadu State Council for Science and Technology (TNSCST), Chairman, Board of Governors, National Design and Research Forum(NDRF. He was born on 2 July 1958, in a village called Kothavadi near Pollachi in Coimbatore district, Tamil Nadu state of India). Prior to taking this assignment he was with Indian Space Research Organisation and served as director, ISRO Satellite Centre (ISAC), Bangalore. During his 36 years of service in ISRO, he had some of the major contributions, including two of the major missions of ISRO, namely Chandrayaan-1 and Mangalyaan. Annadurai has been listed among 100 Global thinkers of 2014 and topped the innovators list. His works are mentioned in textbooks of Tamil Nadu Board of Secondary Education

Early life and education

Annadurai had his schooling in his native village Kodhawady and nearby town Pollachi. He has obtained a bachelor's degree

in engineering (electronics and communication) in 1980 from Government College of Technology, Coimbatore, Tamil Nadu, India, and completed his master's degree in engineering during 1982 from PSG College of Technology, Coimbatore and PhD from Anna University of Technology, Coimbatore, Tamil Nadu in India. He joined ISRO in 1982. As the mission director of INSAT missions, he had some of the original contributions to the INSAT systems maintenance.

Mars Orbiter Mission

India's first mission to Mars, the Mars Orbiter Mission, or *Mangalyaan*, reached the planet on 24 September 2014 completing its 300-day journey. While ISRO has been researching for a Mars mission for many years, the project was only approved by the government in August 2012. ISRO took over a year to work on the spacecraft and bring the project to implementation stage. The Mars Orbiter Mission was launched on 5 November 2013 from the Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh, on the country's east coast. After travelling 670 million kilometres, *Mangalyaan* is now set to study the surface features, morphology, mineralogy and Martian atmosphere to better understand the climate, geology, origin, evolution and sustainability of life on the planet. It is the most cost effective of all the missions sent to the planet by any other country costing India about $74 million.

Chandrayaan I & II

- Chandrayaan-1, was India's first mission to the Moon launched by India's national space agency, the

> Indian Space Research Organisation (ISRO). The unmanned lunar exploration mission included a lunar orbiter and an impactor. India launched the spacecraft by a modified version of the PSLV C11 on 22 October 2008 from Satish Dhawan Space Centre, Sriharikota, Nellore District, Andhra Pradesh about 80 km north of Chennai at 06:22 IST (00:52 UTC). The mission was a major boost to India's space program, and India joined a band of Asian nations (China and Japan) in exploring the Moon. The vehicle was successfully inserted into lunar orbit on 8 November 2008.

During the period 2004–2008, as the project director for Chandrayaan I, he led a team of engineers and scientists that designed and developed the project to carry instrumentation from ISRO and from NASA, ESA, and Bulgaria to accomplish simultaneous chemical, mineralogical, resource and topographic mapping of the entire lunar surface at high spatial and spectral resolutions.

The project was realised within the time frame stipulated and the budget granted. He has paved the way for the future of Indian planetary missions and set an example for the international co-operation bringing the reputed international organisations like NASA, ESA, JAXA to work under the leadership of ISRO.

Chandrayaan I has received many national and international awards including, the coveted Space Pioneers award for science and engineering at 28th International conference on Space development, in Florida USA in 2009.

Director, ISRO Satellite Centre

2015 to 2018 Annadurai was heading ISRO Satellite Centre, Bangalore as director. The centre is responsible for building state of the art satellites for communication, remote sensing, navigation, space science and interplanetary missions.In his tenure as Director of the centre he has overseen making, launching and operationalisation of 30 state of the art satellites

Post Retirement from ISRO

In 2019 Mylswamy Annadurai has been appointed as vice president for Tamil Nadu State Council for Science and Technology. In the same year he has been also nominated as Chairman, Board of Governors,

National Design and Research Forum(NDRF) He uses both the positions effectively for the development of science and technology both at the state and national level, starting from science out reach at school level to guiding some high end collaborative research of social relevance by bringing together research labs, academia and industry ,

Films

- In the movie Mission Mangal based on India's Mars mission, the character of Akshay Kumar is inspired from Annadurai
- In the feature film Chandrayaan based on India's first Moon mission Chandrayaan-1 directed and

produced by Santhosh George Kulangara, his and his family mambers' roles were enacted by south Indian cine artists.

Previous assignments

During his 36years of servive in ISRO Dr Annadurai held various responsibilities. Prior to become the Centre Ditector, he served as programme director for IRS&SSS (Indian Remote Sensing & Small, Science and Student Satellites) that include Chandrayaan-1, Chandrayaan-2, ASTROSAT, Aditya-L1, Mars Orbiter Mission and many Indian Remote Sensing missions. He also contributed to India's National Communication satellite (INSAT) missions as the Mission Director.

He was the member secretary of the task team that prepared Chandrayaan I project report. He is the author of several research papers in his specialization.

Annadurai's career profile is as follow,

- 1982 : Joined ISRO
- 1985-88 : Team leader to develop S/W satellite Simulator
- 1988-92 : Spacecraft operations manager, IRS-1A
- 1992-96 : Spacecraft operations manager, INSAT-2A
- 1993-96 : Spacecraft operations manager, INSAT-2B
- 1994-96 : Deputy project director, INSAT-2C
- 1996-01 : Mission director, INSAT-2C
- 1997-98 : Mission director, INSAT-2D
- 1999-12 : Mission director, INSAT-2E
- 2000-10 : Mission director, INSAT-3B

- 2001-02 : Mission director, GSAT-1
- 2003-11 : Mission director, INSAT-3E
- 2003-05 : Associate project director, EDUSAT
- 2004-09 : Project director, Chandrayaan-1
- 2008-13 : Project director, Chandrayaan-2
- 2011-15 : Programme director, IRS & SSS (Indian Remote Sensing & Small, Science and Student Satellites)
- 2015-18 : Director, ISRO Satellite Centre, Bangalore
- 2019 - : Vice president, Tamil Nadu State Council for Science and Technology
- 2019 - : Chairman, board of governors, National Research and Design Forum

During his holidays, Annadurai tours across the country to meet and interact with the students to encourage them to study science.

Awards and achievements

Annadurai has received more than hundred awards, that include,

Awards From Government

- Padma Shri, 2016, one of the highest civilian awards in India.
- The government of Karnataka awarded him the Rajyotsava Prashasti for Science (2008).

Awards from universities and academia

- Doctor of Science, DSc (Honoris Causa) conferred by Pondicherry University(2009)
- Doctor of Science, DSc (Honoris Causa) conferred by Anna University, Chennai(2009)
- Doctor of Science, DSc (Honoris Causa) conferred by University of Madras, Chennai (2009)
- Doctor of Science, DSc (Honoris Causa) conferred by MGR University, Chennai (2008)
- Eminent Scientist Award from 76th Indian Science Congress – Madurai Kamaraj University Endowment.
- Distinguished Alumni Award, PSG College of Technology, 2009.
- Sir CV Raman Award-2010 from Periyar University, Salem
- Jewel of GCT(Government College of Technology, Coimbatore) by GCT Alumni
- Personality of the year Awarded by St. Johns International School, Chennai
- Hikal Chemcon Distinguished Speaker Award 2010, the 63rd Annual Session of Indian Institute of Chemical Engineers, Annamalai University.
- National Science and Technology Award, 2011, Sathyabama University, Chennai.
- Distinguished Scientist Award, KC College, Mumbai, Diamond Jubilee Award

Awards from ISRO

- Annadurai is the recipient of the Hariom Ashram pretit Vikram Sarabhai Research Award for his

outstanding Contributions to Systems analysis and Space systems management(2004).

- He is also the recipient of a citation from ISRO for his contribution to the INSAT systems Mission management(2003)
- Team Excellence award for his contribution to Indian Space Program(2007).
- ISRO Merit Award 2009
- Team Excellence Award 2010 as team leader of Chandrayaan-1 team
- ISRO Outstanding Achievement award, 2014

National and International Awards from Professional Bodies

- Laurels for Team Achievement Chandrayaan-1, International Academy of Astronautics,2013, Beijing China
- Certificate of Appreciation from Boeing Asian – American professional Association, Houston, USA
- Space Systems award, 2009 from American Institute of Aeronautics and Astronautics, US.
- National Aeronautical Award-2008 from Aeronautical Society of India in recognition of his contributions in the field of satellites/spacecraft
- Fellow, International Academy of Astronautics
- Fellow, Institution of Engineers, India(FIE)
- Fellow, Institution of Electronics and Telecommunication Engineering, India (IETE)
- Fellow, Indian Society for Remote Sensing (ISRS)

- Fellow, Society for shock wave research, Dept.of Aerospace Eng, Indian Institute of Science (IISC), Bangalore
- Fellow, Chennai Science Academy(Formerly Tamil Nadu Science Academy)
- NIQR Bajaj Award for "Outstanding Quality Man 2009"
- H K Firodia awards, 2009 for Science and Technology
- IEI-IEEE Engineering Excellence award 2016 for Contributions and Leadership in Space Technology in service of Humanity
- BHASKARA Award 2016 for his outstanding Scientific Leadership
- SIES (South Indian Education Society) Sri Chandrasekharendra Saraswati National Eminence Award, 2009 for Science and Technology
- "Lifetime Contribution Award" AISYWC-18
- Listed in the TNIE-Uninor Achiever of the year 2009,
- Listed in the Dinamalar-Uninor Achiever of the year 2009,
- Pearl Ratna,2020 by Pearl Education Foundation

Awards from Social & Public Forums

- Vivekananda Award for Human Excellence by Rama Krishna Mission
- Kongu Achiever Award 2009 From NIA Trust, Pollachi.
- Best Tamil Scientist Award, Makkal Viruthu, Makkal TV, 2009
- Amara Bharathi National Eminence Award for Science and Technology, 2010

- Karmaveerar Kamaraj Award,2010 from Chennai Mhahajana sabha
- Dr Rajah Sir Muthiah Chettiar Birthday Commemoration Award for 2012.
- "Listed among 100 Global thinkers of 2014 and topped the innovators list "
- Lifetime achievement award, 2015, SRV Schools, Trichy
- Tamilan Award 2016, for Science and Technology by Puthiya Thalaimurai TV
- Global Indian for Science, 2017 awarded by ICICI and Times Group
- Life Time Achievement Award in the field of science and technology by Union Bank of India
- C.Pa.Aditanar Literary Award 2013
- Poorna Chandra award from Rotary Club, Coimbatore.
- Tamil Ma-mani award, from Tirupur Tamil Sangam.
- Tamil Achiever Award,2011 by Bharathi Tamil Sangam, Kolkata.
- Example to Youth Award.
- Kalingarayar Award -2016, by Kongu Charitable Trust, Tamil Nadu
- Citizen Extraordinary Award-2014, by Rotary Club Bangalore
- Lifetime Achievement – Muthamizh Award-2108, Muthamizh Peravai
- "Mars Man", by Front liners- 2018, Kuwait,
- Lifetime Achievement Award, 2019, Rotary International Pollachi

- Life Time Achievement Award, 2019, by Govt Higher Secondary School Alumni, Velandampalayam, Tamil Nadu
- Mahatma Gandhi Award, 2019, Gandhi World Foundation,
- Lifetime Achievement award, 2019, Muscat Tamil Sangam,
- Sri Adhi Sankara Award, 2019, Shri Adhi Sankara Peravai,
- Sony YAY award,2020,
- Best Conference paper in the Innovations and Enterpreneurship, Annual Intl Conference by Industry Studies Association, USA, 3-4 Jun 2021 that carried US $ 500 cash prize and an award plaque

Annadurai's publications and works are being widely referred by satellite operator's, one of his work has been referred in a US patent.

He has written five books in Tamil namely,

- 1.Kaiyaruke Nila
- 2.Siragai virikkum Mangalyaan
- 3.Valarum Ariviyal
- 4.Ariviyal Kalanjiyam and
- 5.Vinnum Mannum.

The Book" Kaiyaruke Nila" has won S. P. Adithanar Literary award for the year 2013.

S. K. Shivakumar

S. K. Shivakumar (1953 – 13 April 2019) was an Indian scientist from Karnataka state who worked at the Indian Space Research Organisation (ISRO) centres. He was awarded the Padma Shri, the fourth highest civilian award of India, in 2015.

Early life and education

Shivakumar was born in 1953 in Mysore in Mysore State (now Karnataka), India. He earned a BSc from Mysore University followed by a BE in Electrical Communications Engineering and an MTech in Physical Engineering from the Indian Institute of Science, Bangalore. He received PhD in Electronics from Kuvempu University in 2014.

Career

He joined the Indian Space Research Organisation (ISRO) and started his career at its ISRO Telemetry, Tracking and Command Network (ISTRAC), Sriharikota in 1976.

He later worked in its Indian Space Research Organisation Satellite Centre (ISAC) from 1978 to 1998. He was the project director for the development of the 32-metre (105 ft) dish antenna of the Indian Deep Space Network which is used for telemetry for the missions such as the Chandrayaan-1, India's first lunar exploration mission and Mangalyaan, India's first interplanetary mission.

He was involved in several satellite missions such as Bhaskara, Indian National Satellite System (INSAT), Ariane Passenger Payload Experiment (APPLE) and Indian Remote Sensing Programme (IRS). Shivakumar was the mission director of the IRS-1B and IRS-1C satellite missions. He also served as the director of the ISTRAC between September 1998 and November 2010. Shivakumar was later the associate director of the ISAC from November 2010 to June 2012 and director of the program from July 2012 to March 2015. As of 2019, he was serving as chairman of Karnataka Science and Technology Council.

Death

He died on 13 April 2019 at the age of 66 in Bangalore and was cremated at the Banashankari Crematorium. The cause of death was reported to be post-hepatic jaundice.

Awards

- Padma Shri, the fourth highest civilian award of India, in 2015
- Karnataka Rajyotsava Award (2008)
- Nadoja Award (2013)
- Honorary Doctorate (DSc) by the Mysore University

K. Radhakrishnan

Koppillil Radhakrishnan (born 29 August 1949) is an Indian space scientist who headed the Indian Space Research Organisation (ISRO) between November 2009 and December

2014 as Chairman of Space Commission, Secretary of the Department of Space and Chairman of ISRO. Prior to this, he was the Director of Vikram Sarabhai Space Centre (2007-2009) and Director of National Remote Sensing Agency (2005-2008) of the Department of Space. He had a brief stint of five years (2000-2005) in the Ministry of Earth Sciences as Director of Indian National Centre for Ocean Information Services (INCOIS).

Presently, he is the Chairperson of the Board of Governors of Indian Institute of Technology (IIT), Kanpur and Chairman of the Standing Committee of the IIT Council besides being Honorary Distinguished Advisor in the Department of Space/ISRO.

He is a Fellow of the Indian National Academy of Engineering; Fellow of the National Academy of Sciences, India; Honorary Life Fellow of the Institution of Engineers,

India; Honorary Fellow of the Institution of Electronics and Telecommunication Engineers, India; Member of the International Academy of Astronautics; Fellow of the Andhra Pradesh Academy of Sciences; Honorary Fellow of the Kerala Academy of Sciences; Fellow of the Indian Society of Remote Sensing; and Fellow of the Indian Geophysical Union. He is an accomplished vocalist (Carnatic music) and Kathakali artist.

Penguin Random House India published his autobiography *My Odyssey: Memoirs of the Man Behind the Mangalyaan Mission* (ISBN 978-0-670-08906-2), co-authored by Radhakrishnan and Nilanjan Routh, in November 2016.

Education and Personal Life

Koppillil Radhakrishnan hails from Irinjalakuda in Thrissur district, Kerala. After his schooling at the National High School, Irinjalakuda, he did two-year Pre-degree studies (Mathematics, Physics, Chemistry) at Christ College, Irinjalakuda.

He studied Electrical Engineering at the Government Engineering College, Thrissur and acquired BSc (Engg.) degree in First Class with Honours from Kerala University in 1970. He did post-graduate studies in management at Indian Institute of Management Bangalore in 1974-76. He obtained doctorate from the Indian Institute of Technology Kharagpur, in 2000, for the thesis : 'Some Strategies for the Management of Indian Earth Observation System'.

Radhakrishnan married Padmini Kizhakke Valappil from Irinjalakuda in 1983. Padmini worked with State Bank of Travancore from 1980 to 2010.

Indian Space Research Organisation

Radhakrishnan joined ISRO in May 1971 at the Space Science & Technology Centre at Thiruvananthapuram (the present Vikram Sarabhai Space Centre) as a design and development engineer of electro-mechanical devices.

Later he worked on system planning and technology management for avionics systems of SLV-3, ASLV and PSLV. During 1981-97, at the ISRO Headquarters, he oversaw the preparation and review of annual budgets of ISRO, formulation

of decade profile and Five Year Plans for Indian Space programme and the related techno-economic analysis.

Remote Sensing Applications

As Project Director, he set up a chain of regional remote sensing service centres (RRSSC) at Bangalore, Nagpur, Kharagpur, Jodhpur and Dehradun for capacity building in central and state government agencies. While he was the Director, RRSSCs came to prominence in the national remote sensing application missions including the Integrated Mission for Sustainable Development (IMSD) aimed at generation of spatial database of natural resources and action plans for sustainable development of land and water resources.

Later, Radhakrishnan succeeded as the Mission Director of IMSD and moved to National Remote Sensing Agency in Hyderabad. IMSD was considered as largest remote sensing application experiment ever done in the world using a meticulous participatory approach. As the Director of National Remote Sensing Agency, he scripted India's modern multi-mission ground station for Earth Observation Satellites.

Space Transportation System and Chandrayaan-1 Mission

While at Vikram Sarabhai Space Centre as its Director, he oversaw five successful launches of PSLV including development of its high-end version PSLV –XL that lofted Chandrayaan-1 in October 2008 as well as formulation of Indian Human Spaceflight programme.

Chief of India's Space Programme

As India's space chief from November 2009 to December 2014, Radhakrishnan led ISRO to achieve 37 space missions including several historic feats including Mars Orbiter Mission; flying Indian Cryogenic Engine on GSLV; the first experimental flight of the GSLV Mk III; a re-entry experiment of an un-manned crew module; and new space capabilities through IRNSS (1A, 1B, 1C) for navigation; GSAT-7 for strategic communication; and RISAT-1 for microwave radar imaging. ISRO completed two joint satellite missions (Megha Tropiques and SARAL) with the French National Space Agencyand inked another agreement with NASA to jointly build an advanced Radar Imaging Satellite. India's standing in the global space market was enhanced as PSLV launched 18 commercial satellites for 11 countries.

Through an inclusive organisational process, Radhakrishnan charted out clear programmatic directions and nurtured younger generation of leaders for carrying forward the legacy of ISRO. Re-defining the *Chandrayaan-2* mission with Indigenous lander and rover and extending the application of space technologies and tools to all central ministries are highlights of his leadership regime at ISRO. He worked to enhance the partnership with the Indian space industry for the production of operational launchers and satellites.

During his leadership, ISRO received the 2014 Gandhi Peace Prize; the 2014 Indira Gandhi Prize for Peace, Disarmament and Development; the 2014 Knowledge Economy Network KEN Award; the 2014 CNN-IBN Indian of the Year-Lifetime Achievement Award; the 2014 Global Game Changer Award by

the Marico Innovation Foundation; and the 2013 CNBC-18 India Business Leader Award-BRAND INDIA.

Mars Orbiter Mission (Mangalyaan)

Mars Orbiter Mission (MOM; aka *Mangalyaan*) was conceived, planned and executed, within four years (2010-2014), establishing India as the first country to have successful mission to Mars in its maiden attempt, and at significantly low cost (INR 4.5 Billion) .

Geosynchronous Satellite Launch Vehicle and Indian Cryogenic Stage

GSLV had a checkered history in its initial flights of 2001-2007 and they were powered by cryogenic upper stage of Russia. After failure of the Indian Cryogenic upper stage on GSLV in April 2010 (GSLV-D3) and recurrence one more failure of GSLV with Russian Cryogeinc upper stage (GSLV-F06) in December 2010, Radhakrishnan steered ISRO towards the landmark success in January 2014 GSLV-D5. This marked the beginning of the successful series of GSLV with Indian Cryogenic Upper Stage.

Ocean Observation and Information Services

Radhakrishnan had a stint of five years the Ministry of Earth Sciences to set up, Indian National Centre for Ocean Information Services (INCOIS). In the aftermath of the Indian

Ocean Tsunami disaster of December 2004, he emerged as the Project Director to set up the Indian Ocean Tsunami Warning Centre.

Kathakali and Carnatic Music

Radhakrishnan is a Carnatic music and Kathakali enthusiast and performer. Radhakrishnan was drawn into the world of performing arts from childhood. After formal training in Kerala Natanam, under Professor Thrippunithura Vijayabhanu, he had training in Kathakali dance under Guru Pallippuram Gopalan Nair, Kalanilayam Raghavan and Shri T.V.A Varier. Also, he was trained in Carnatic music by eminent musicians like Prof. Vechoor Harihara Subramania Iyer, Dr. R.K. Srikantan, Dr. Nookala Chinna Satyanarayana; currently he is student of Vidwan R.S. Ramakanth. Dr. Radhakrishnan has performed at Bengaluru Sangeethotsav, Sankranthi Music Festival of RK Srikantan Trust, Swaralaya, Bangalore Centre for Kathakali and Arts, JSS Sangeetha Sabha, Chembai Vaidyanatha Bhagavathar Music Festival at Chennai. He has been singing at the Guruvayoor Chembai Sangeetholsavam every year since 2008.

Positions held

He has held several key positions in ISRO and was one of the key people behind India's *Chandrayaan-1* moon mission. He has held the following positions:

- Project Director, Regional Remote Sensing Service Centres under the umbrella of National Natural Resources Management System (1987–1989)

- Director, Regional Remote Sensing Service Centres under the umbrella of National Natural Resources Management System (1989–1997)
- Director, Budget and Economic Analysis, Indian Space Research Organisation/Department of Space, Bangalore, India (1987–1997)
- National Mission Director, Integrated Mission for Sustainable Development and a Deputy Director of the National Remote Sensing Agency (1997–2000)
- Director, Indian National Centre for Ocean Information Services (2000–2005)
- Project Director, Indian Tsunami Warning System (2005)
- Vice Chairman - Intergovernmental Oceanographic Commission (IOC) of UNESCO (2001–2005)
- Founding Chairman, Indian Ocean Global Ocean Observing System (2001–2006)
- Regional Coordinator, Indian Ocean for the International Argo Project (2001–2005)
- Director, National Remote Sensing Agency, Department of Space (2005–2008)
- President, Indian Society of Remote Sensing (2005-2007)
- Vice President, Indian Geophysical Union (2007-2009)
- Member of the Indian delegation to the United Nations Committee on the Peaceful Uses of Outer Space (2006-2009)
- Director, Vikram Sarabhai Space Centre, Thiruvananthapuram, India (2007–2009)
- Chairman, 'Working Group of the Whole' of S&T Sub-Committee of UN COPUOS (2008 & 2009)

- Chairman, Indian Space Research Organisation, Bangalore, India (2009-2014)
- Chairman, Board of Antrix Corporation, Bangalore, India (November 2009-July 2011)
- Chairman, Indian Institute of Space Science and Technology, Thiruvananthapuram, India (2009-2014)
- Member, Planning Committee of National Natural Resources Management System (2009-2014)
- Chairman, NNRMS Standing Committee on Technology & Training (2009-2014)
- President, Astronautical Society of India (2010-2014)
- Member of CSIR Society and Member of CSIR Governing Council (2010-2013)
- Chairman, Research Council of National Aerospace Laboratory (2010-2013)
- Ex-officio Member of Scientific Advisory Committee to Prime Minister (2009-2014)
- Ex-officio Member of Scientific Advisory Committee to Cabinet (2009-2014)
- Chairman, Indian Institutes of Engineering Science and Technology, Shibpur, India (2014–2017)
- Adviser, Department of Space/Indian Space Research Organisation (2016 & 2017)
- Honorary Distinguished Adviser, Department of Space/Indian Space Research Organisation (March 2018 – present)
- Chairperson, Board of Governors of Indian Institute of Technology, Kanpur (February 2019 - present)
- Chairman, Standing Committee of the IIT Council (December 2019 - present)

Major Awards and honours

- 2014: Radhakrishnan received the Padma Bhushan Award for contribution to Science and Engineering, especially in the field of Space Science and Technology.
- 2014: Named one of *Nature*'s ten "people who mattered" of 2014 on 18 December 2014, along with Radhika Nagpal, and others.
- 2003: K.R. Ramanathan Memorial Gold Medal of Indian Geophysical Union
- 2005: VASVIK Industrial Research Award
- 2006: Silver Jubilee Honour by Ministry of Earth Sciences
- 2008: BHASKARA Award of Indian Society of Remote Sensing
- 2008: Dr. Y. Nayudamma Memorial Award of the A.P Academy of Sciences
- 2009: Social Sciences Award of the International Academy of Astronautics
- 2010: Vikram Sarabhai Memorial Award of Indian Science Congress
- 2010: Distinguished Alumnus Award of IIT, Kharagpur
- 2010: Distinguished Alumnus Award of IIM, Bangalore
- 2014: ISRO's Lifetime Achievement Award
- 2014: The Allan D. Emil Award of International Astronautical Federation
- 2014: Ernst & Young Lifetime Achievement Award

- 2014: Technovation-Sarabhai Award of Indian Electronics & Semiconductor Association
- 2015: Lifetime Achievent Award of Union Bank of India
- 2015: Lifetime Outstanding Innovation Award Indore Management Association
- 2015: Bharat Asmita Vigyan Tantragyaan Shreshta
- 2015: P.C. Chandra Purashkar for Lifetime Achievement
- 2016: Lifetime Achievement Award, Engineers' Forum, Nagpur
- 2017: Global Indian (Science) Award of Times Network
- 2018: Qimpro Platinum Standard 2018 (Business)

He has been conferred Honorary Doctorates by IIT Kharagpur and 12 Indian universities.

Jitendra Nath Goswami

Jitendranath Goswami (born 18 November 1950) is an Indian scientist from Jorhat, Assam. He was the Chief Scientist of Chandrayaan-1, and was also the developer of this project. He served as a director of Physical Research Laboratory situated at Ahmadabad, Gujarat. He was also associated with Chandrayaan-2 and Mangalyaan.

Education

Goswami started schooling at Jorhat. In 1965, he got 6th position in higher secondary examination conducted by

AHSEC. Then he enrolled in Cotton College to study Physics. He got MSc Degree from Gauhati University and joined Tata Institute of Fundamental Research for PhD. In this time period he also worked as a post-graduate research scholar at the University of California, Berkeley. In 1978, he got PhD degree from Gujarat University.

Research

After PhD, he worked as a research scientist in many prestigious institutes, like UC Berkeley, Washington University, Lunar and Planetary Institute and Max Planck Institute. His main subject of research is study of Solar System and Astrophysics. He and his associate scientists have proven that the main resource of energy of Solar System at the time of its origin was 26Al nuclide in its half life. He has also worked on Cosmic Rays, Tectonic Plates and concluded many theories. From Physical Research Laboratory, he was served as Scientist of exploration projects of ISRO at its preliminary state. He was associate scientist of Cosmic Ray experiment and chief scientist of Lunar Samples at spacecraft Spacelab-3. He also served on the Physical Sciences jury for the Infosys Prize from 2016 to 2018.

Awards

- Youth Scientist Award by Indian National Science Association (1978)
- NASA's Public Service Group of Achievement Award (1986)
- Shanti Swaroop Bhatnagar Award (1994)

- Kamal Kumari National Award for science and technology (2003)
- Axford award by Asia Oceania Geoscience Society (2014)
- Asom Ratna (2015), highest civilian award of Government of Assam
- Padma Shri, 2017 by Government of India.

He was elected as president of Astronomical Society of India in 2007. He is a member of The World Academy of Science, Indian Academy of Sciences, European Association of Geochemistry and many other national and international association of Astronomy.

Madhavan Chandradathan

M. C. Dathan is an Indian space scientist and former director of the Vikram Sarabhai Space Centre (VSSC). The Government of India honoured him, in 2014, by awarding him the Padma Shri, the fourth highest civilian award, for his contributions to the fields of science and technology. In May 2016, the Government of Kerala appointed MC Dathan as the scientific advisor to chief minister.

Biography

Madhavan Chandradathan was born to Madhavan and Vasumathy, in Varkala. He graduated in chemical engineering from the Government Engineering College, Thrissur in 1971 and secured a master's degree (MTech) from the Birla Institute of Technology in 1985.

Chandradathan started his career in 1972, by joining the Indian Space Research Organization (ISRO) where he worked for the SLV-3 project, the development of solid propellant formulations. He also contributed to the realization of solid motors for SLV-3, ASLV and PSLV projects. Later, Chandradathan took up the assignment of developing rocket nozzles primarily for solid motors. He became the head of the ablative nozzle production unit in 2000, where he remained till 2004. During this period, his team developed the flex nozzle for the S200 motor and the S200 booster for the GSLV Mk-III project.

He was promoted to Chief Executive of the Solid Propellant Plant (SPROB) for the PSLV and GSLV boosters. In this position, Chandradrathan oversaw the establishment of a new Solid Propellant Plant (SPP), which was commissioned in 2008.

Chandradathan became the Director of the Satish Dhawan Space Centre, SHAR (SDSC), in 2008. During his tenure as the Director, Chandradathan is reported to have contributed to the improvement of production levels of solid boosters. He is also credited with two ground tests for S200 segments of the GSLV Mk-III, expansion of the facilities, and the development of a new Mission Control Centre and Launch Control Centre.

In January 2013, he became the Director of the Liquid Propulsion Systems Centre (LPSC), which controlled the Thiruvananthapuram, Mahendragiri and Bangalore campuses of the ISRO. In June 2014, he was made the Director of the Vikram Sarabhai Space Centre (VSSC).

He was also the head of the launch authorization board of Chandrayaan-1 project.

In May 2016, the Government of Kerala appointed MC Dathan as the scientific advisor to chief minister Pinarayi Vijayan.

Honours

Chandradrathan is a recipient of many honours and awards, including *Performance Excellence Award* (2009) from ISRO, *Outstanding Chemical Engineer Award* (2009) from the Institution of Engineers (India) (IEI) and *Individual Service Award* (2006) from ISRO.

In 2014, the Government of India honoured him with the civilian award of Padma Shri.

Chandradathan has attended many seminars and conferences to give keynote addresses. He has also published many articles in such journals of repute as the International Astronautical Federation.

- *"Investigations of Thrust Oscillations in Large Segmented Solid Rocket Motors During Ground Tests"(PDF). International Astronautical Federation. 2014. Retrieved 28 October 2014.*