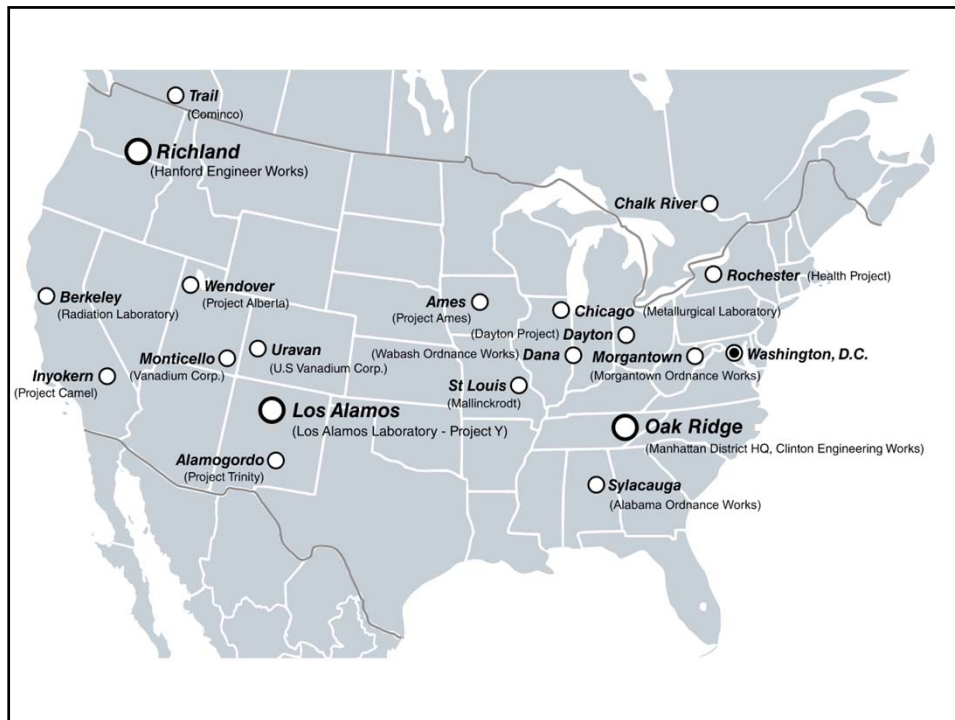




Manhattan Engineer District

- Groves set up his office in New York and the project became officially known as Manhattan Engineer District, a deliberately bland and misleading choice
- At its peak, it involved 30 locations in US, UK and Canada
- Nearly 130,000 people were employed although the bulk of these were in construction
- The total expenditure was \$2 billion against the original budget of \$90 million
- An immediate problem was to source uranium since the US and Canadian mines were small, so the project bought 1250 tons of high quality uranium ore from a mine in the Belgian Congo
- In fact the ore had been in storage in New York since 1940 as a far-sighted precaution by the head of the mining company, Edgar Sengier
- Secrecy for the project was absolute - not even Senator Harry Truman as Chairman of the Senate Special Committee to Investigate the National Defense Program could find out any information as to where all this money was going

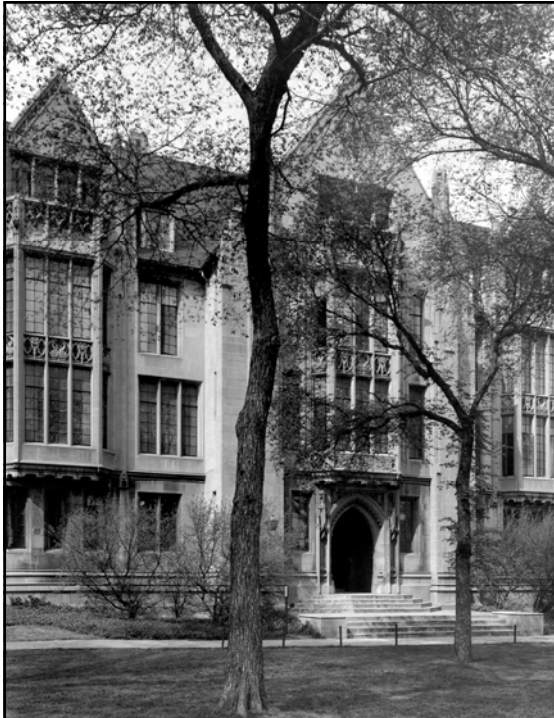
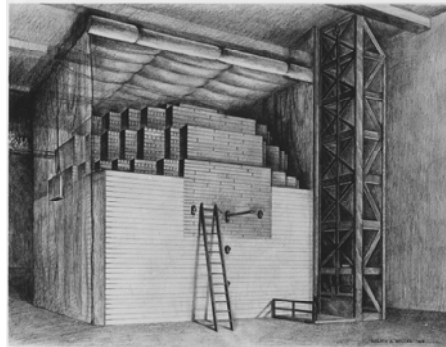


Chicago Pile-1

- To test whether it was possible to sustain a chain reaction, a small reactor was built to the design of Enrico Fermi in a squash court at the University of Chicago
- Compton decided against asking the university for permission to undertake such a risky experiment on campus
- *"The only answer he (President of the University) could have given would have been—no. And this answer would have been wrong."*
- Like the French and Germans before him, Fermi had concluded that graphite wasn't suitable as moderator
- Leo Szilard, as a chemical engineer, recognised that commercial grade graphite contained contaminants from the production process that absorbed neutrons and that a higher purity should work
- With emergency procurement powers, they were able to obtain the quality that they needed which required a different production process

Chicago Pile-1 (2)

- Construction started on 16 November 1942 and was ready for operation on 2 December
- By mid-afternoon Fermi had the result he was looking for - the first ever self-sustaining controlled chain reaction lasting 4.5 minutes
- Compton rang Conant to give him the news
- *Compton: The Italian navigator has landed in the New World.*
- *Conant: How were the natives?*
- *Compton: Very friendly.*



Duillio DiCostanzo,

B.S., M.S. (Physics)

One of 130,000 people on the Manhattan project, Dewey was Foreman of the Precision Metal Shop of the University of Chicago's Metallurgical Laboratory that designed many of the metal components used.

He was on the suicide squad on 2 December 1942 ready to pour cadmium nitrate on Chicago Pile-1 had it appeared that the reaction would go out of control after reaching critical mass for the first time.

Uranium enrichment

- **Clinton Engineer Works** in East Tennessee - later known as **Oak Ridge National Laboratory** – was established in East Tennessee to the west of Knoxville in 1943
- Produced enriched uranium by 3 different methods, all very slow
- One of the processes was based on Lawrence's cyclotron
- Eventually, all 3 processes were run in series increasing the rate of production
- By August 1945, only 65 kg of enriched uranium (80% U-235) had been produced, enough for only one bomb, **Little Boy**, which was dropped on Hiroshima
- This did not allow for any testing - it would just have to work!

Plutonium production

- **Hanford Engineer Works**, Washington state
- This was the first large scale plutonium production facility
- It was another graphite-moderated reactor
- The first production of plutonium was made in the X-10 graphite reactor at Clinton but Hanford was on a much grander scale
- In practice once production was scaled up, it was much easier to produce than enriched uranium
- The first reactor was completed on September 1944 and produced its first plutonium in November
- 2 identical reactors were brought online in December and February allowing consistent production of plutonium for shipment to Los Alamos
- Heavy water was produced in Canada, but was not widely used in the bomb production as high quality graphite was proving to be a very convenient neutron moderator

Los Alamos

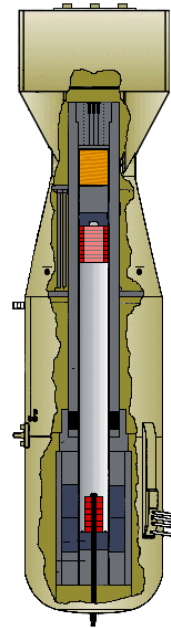
- Groves and Oppenheimer were seeking a remote location for the scientific teams involved in the design and construction of the bombs
- This work involved physics, chemistry, metallurgy, engineering and ordnance aspects
- Oppenheimer had a ranch in New Mexico that he used for horse riding and suggested a mesa-type plateau that he knew outside of Santa Fe
- Groves thought that this location was ideal in that it was remote and had only a single access road

Los Alamos (2)

- Oppenheimer initially believed that 50 scientists and 50 technicians would be enough, but Groves increased that to 300
- At the peak, there were 3,000 scientific and technical staff
- Officially it was under the control of the University of California under contract with the Army as quite a few scientists were reluctant to join the military or wear uniforms
- This unusual arrangement worked well despite the potential for conflicts

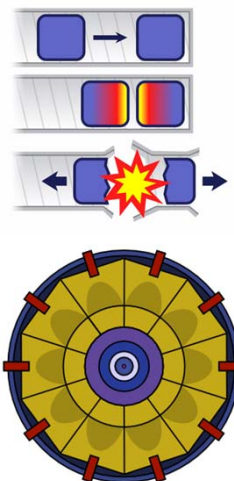
Gun-type design

- The key design problem was to avoid creating a critical mass until you needed the bomb to explode
- For Little Boy, the solution was to fire a hollow cylinder (39kg) down a "gun" barrel at 300 m/s using cordite onto a spike or spindle (26 kg)
- The size and shape of each component made them sub-critical until they were combined
- The scientists were confident that the gun-type weapon would work once Oak Ridge had delivered enough uranium
- They turned their attention to plutonium, which was easier to produce in quantity and should work well for the gun-type design
- It didn't



Implosion-type design

- The Pu-240 isotope was unstable which was highly likely to lead to early detonation or at least "fizzling"
- The implosion-type bomb design they came up with was very much more complex and difficult to implement than the gun-type design
- Explosives would be used to compress a sphere of plutonium to produce the critical mass
- It took a full year of intensive effort from nearly the whole Los Alamos team to work out how to do this and to design and build a workable bomb
- Even so, it would need to be tested as they had pushed the boundaries of the science so far that they could not be certain that it would actually work in practice



John von Neumann

- b. 1903 Hungary d. 1957
- Non-practicing Jewish family
- One of the greatest mathematicians of the 20th C
- Worked with Max Born at Göttingen
- Made major contributions to pure and applied maths, physics and computer science
- Had a remarkable ability for calculations
- Pre-war, he became an expert in the mathematics of explosions
- His work on implosion was essential
- He also advised that the effect of the explosion would be maximised if the detonation occurred in the air rather than at ground level



Trinity

- Trinity was the code name given to the test of **Gadget** at Alamogordo Field in New Mexico
- Gadget was the name used for security and psychological reasons (rather than saying bomb all the time)
- At 05:30 am on 16 July 1945 Gadget exploded with an energy equivalent of around 20 kilotons of TNT, leaving a crater in the desert 76 m wide
- The shock wave was felt over 160 km away, and the mushroom cloud reached 12 km in height
- It was heard as far away as El Paso, Texas, so Groves issued a cover story about an ammunition magazine explosion
- They had just enough plutonium left over to make **Fat Man** that would be used on Nagasaki



Yalta Conference

- 4 to 11 February 1945 Roosevelt, Churchill and Stalin met at Yalta in Crimea
- Most of the key decisions related to the war against Germany and the future of Eastern Europe
- In relation to Japan, Stalin agreed to enter the fight "in two or three months after Germany has surrendered and the war in Europe is terminated"
- The USSR and Japan had entered into a 5 year non-aggression pact 13 April 1941 so Stalin would have to break the agreement
- Roosevelt and Churchill had decided not to say anything to Stalin about the atomic bombs
- Not that it mattered, as Klaus Fuchs had been keeping the Soviets well informed
- But it added to the growing distrust

Potsdam Conference

- 12 April Roosevelt died and was replaced by Truman
- 8 May VE-Day
- 5 July The outcome of the UK general election was clear with Atlee replacing Churchill but the final results were not announced until 26 July
- 17 July to 2 August Both Churchill and Atlee attended the Potsdam conference
- As at Yalta, most of the conference involved plans for Germany and arguments about Soviet plans for Eastern Europe
- The USSR confirmed that it would enter the war on 15 August, in line with the agreement at Yalta
- 26 July US, Britain, and China released the Potsdam Declaration
- The USSR was not a party to it since it was still not at war with Japan
- And the US and Britain saw an opportunity to end the war without it
- There was now even less trust between the parties

Potsdam Declaration

- 1) *We (leaders of US, China, UK) have conferred and agree that Japan shall be given an opportunity to end this war*
- 2) *The prodigious land, sea and air forces of (US, China, UK), many times reinforced by their armies and air fleets from the west, are poised to strike the final blows upon Japan ...*
- 3) *The result of the futile and senseless German resistance to the might of the aroused free peoples of the world stands forth in awful clarity as an example to the people of Japan ...*
- 4) *The time has come for Japan to decide whether she will continue to be controlled by those self-willed militaristic advisers whose unintelligent calculations have brought the Empire of Japan to the threshold of annihilation, or whether she will follow the path of reason*
- 5) *Following are our terms. We will not deviate from them. There are no alternatives. We shall brook no delay.*

Potsdam Declaration (2)

- 6) *There must be eliminated for all time the authority and influence of those who have deceived and misled the people of Japan into embarking on world conquest, for we insist that a new order of peace, security and justice will be impossible until irresponsible militarism is driven from the world.*
- 7) *Until such new order is established and until there is convincing proof that Japan's war-making power is destroyed, points in Japanese territory to be designated by the Allies shall be occupied to secure the achievement of the basic objectives were here setting forth. ...*
- 8) *... Japanese sovereignty shall be limited to the islands of Honshu, Hokkaido, Kyushu, Shikoku and such minor islands as we determine*
- 9) *The Japanese military forces, after being completely disarmed, shall be permitted to return to their homes with the opportunity to lead peaceful and productive lives*

Potsdam Declaration (3)

- 10) *We do not intend that the Japanese people shall be enslaved as a race or destroyed as a nation, but stern justice will be meted out to all war criminals, including those who have visited cruelties on our prisoners ...*
- 11) *Japan shall be permitted to maintain such industries as will sustain her economy and permit the exaction of just reparations in kind, but not those which would enable her to re-arm for war ...*
- 12) *The occupying forces of the Allies shall be withdrawn from Japan as soon as these objectives have been accomplished and there has been established in accordance with the freely expressed will of the Japanese people a peacefully inclined and responsible government*
- 13) *We call upon the government of Japan to proclaim now the **unconditional surrender** of all Japanese armed forces, and to provide proper and adequate assurances of their good faith in such action. The alternative for Japan is prompt and utter destruction."*

Potsdam Declaration (4)

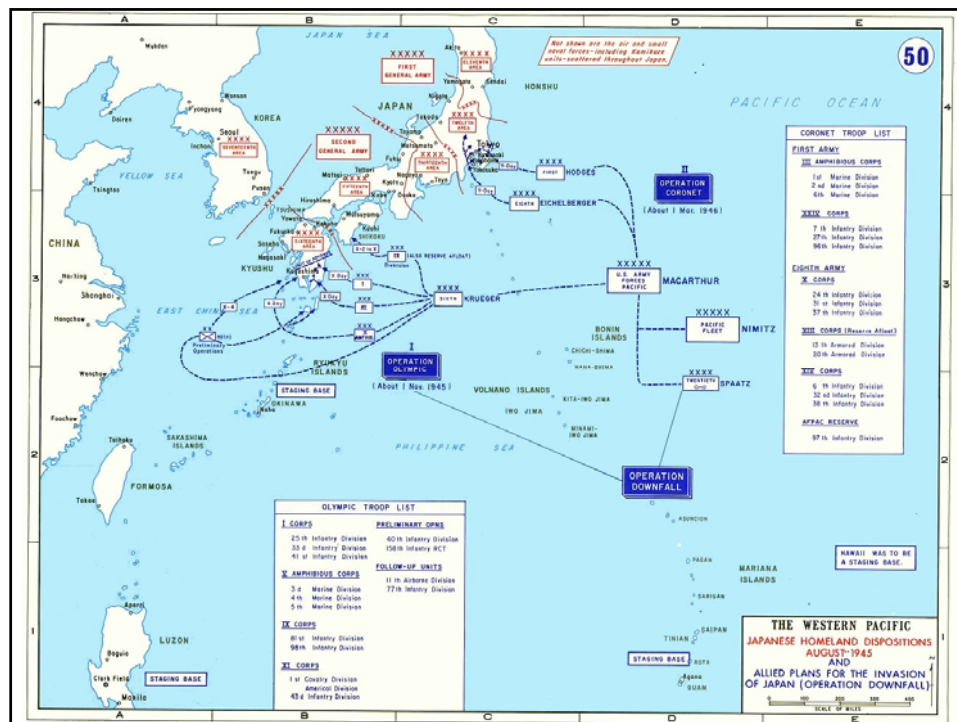
- The message is clear:
 - No negotiations with the government that brought on the war
 - The militarists must be crushed completely
 - All available force would be used to force a surrender
- These points are important in the context of future debates over whether the use of the bombs was an immoral act
- The declaration had some deliberate ambiguities particularly about the fate of the Emperor but these were largely used as an excuse by the war faction to maintain its dominance of the government
- The Japanese response was based around the word *mokusatsu* (lit. "killing with silence"), which the US interpreted as meaning "rejection by ignoring", but it could also mean "withholding comment"
- The Japanese government had been naively seeking for some time to open up high level negotiations with the USSR but Stalin had been stalling

The air war

- Japan was now suffering severe shortages of ships, planes, materials, food, oil as well as major damage to military and civilian infrastructure
- It was effectively under blockade with its navy, air force and merchant fleet having been largely destroyed
- Its armies had been defeated or were being pushed back nearly everywhere
- From late 1944, the US bombing campaign had changed its tactics
- On 9 March 1945, 325 B-29s carrying nearly 500,000 incendiary cylinders of jellied petroleum attacked Tokyo in a howling gale for the loss of only 12 planes
- At least 100,000 Japanese were killed, mostly civilians, more than a million fled the city
- These attacks continued on yet more cities killing civilians in large numbers
- Leaflets were dropped warning of attacks but the Japanese were ordered not to read them

Invasion plans

- Planning for **Operation Downfall** had started early
- There were the only 2 sites deemed suitable for major landings
- **Operation Olympus**, the invasion of the southern island of Kyushu with 11 infantry and 3 marine divisions was scheduled for 1 November 1945
- **Operation Coronet**, the invasion of the main island of Honshu via the Kanto plain with 20 infantry and 3 marine divisions was scheduled for 1 March 1946
- The latter would include Australian, British and Canadian troops
- Despite its weakened state, the IJA would have been able to muster a larger number of troops than the attackers for the defence of Kyushu
- Estimates of potential Allied casualties varied enormously from 100,000 to 500,000
- From the recent experience on the smaller islands, there were good reasons to believe that the numbers could be very high given that this was an invasion of the homeland
- Alternatives to invasion were to be preferred



Casualties on Saipan, Iwo Jima, Okinawa

- **Saipan: 15 June to 9 July 1944**
 - USA: 13,790 casualties, 3,426 KIA, 10,364 WIA
 - Japan: of ~30,000 Japanese defenders, 921 were taken prisoner.
 - Some 20,000 Japanese civilians perished including over 1,000 who committed suicide
- **Iwo Jima: 19 February to 26 March 1945**
 - USA 26,040 casualties, 6,821 killed, 19,217 wounded
 - Japan 17,845–18,375 KIA/MIA 216 taken prisoner, ~3,000 in hiding
- **Okinawa: 1 April to June 22, 1945**
 - USA: 82,000 casualties, over 12,500 KIA/MIA
 - Japan: 110,071 KIA, 7,401 CIA and 149,425 Okinawans were killed, 3,400 CIA

The end game

- The key scientific leaders such as Oppenheimer, Lawrence, Fermi and Compton were still very much in favour of using the bombs
- But there was growing opposition to using within the team
- Formally, the leader of the dissenters was James Franck but the key driver was Leo Szilard
- Many of them had been driven to work on the bomb by the need to beat Germany to it
- They now didn't see a reason for using the bombs
- 17 July a petition signed by 69 scientists was sent to Truman
- Even if Truman ever saw it, he was fully committed to the bombs being used
- Groves responded by excluding the scientists from any further involvement

The end game (2)

- The final list of targets for the atomic bombs was Hiroshima, Kokura, Niigata and Nagasaki
- Secretary of War Stimson had kept removing Kyoto from the list because of its cultural heritage which was exactly the reason Groves and others kept putting it back on the list
- Stimson won out in the end
- None of these cities had experienced significant air attack previously - by deliberate choice
- Which of the actual targets were attacked would depend on the cloud cover on the day

The end game (3)

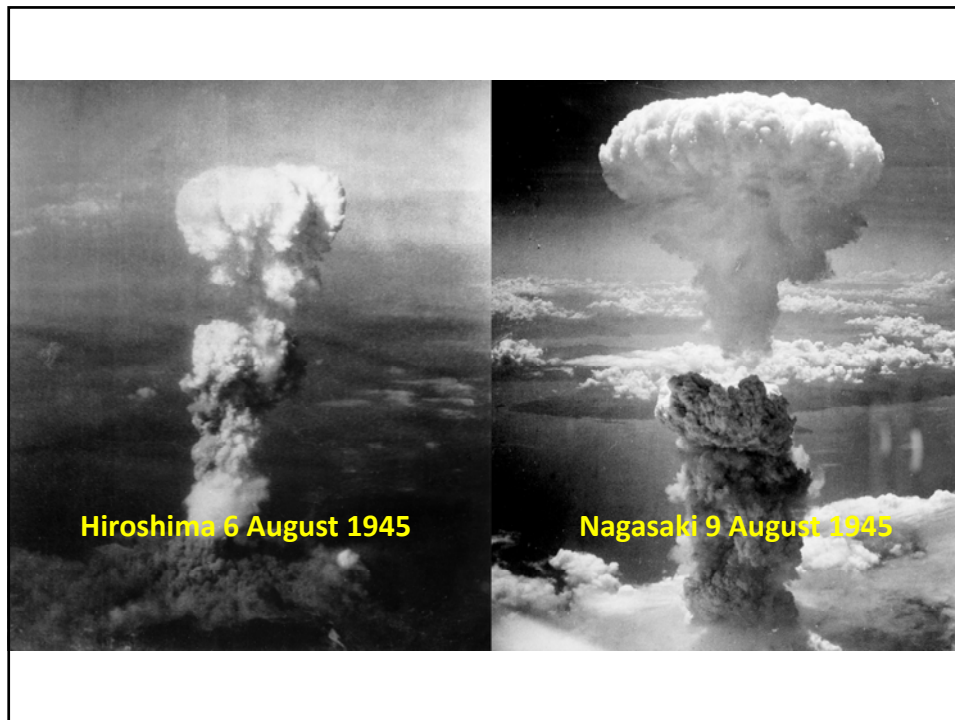
- 6 August, Little Boy was dropped over Hiroshima
- About 70,000 to 80,000 people, or some 30% of the population of Hiroshima, were killed immediately and another 70,000 injured
- The reaction of the Japanese leaders was largely denial and incomprehension
- They still pinned some small hope that Stalin might mediate a peaceful outcome



The end game (4)

- 8 August the USSR forces invaded Manchuria, a week earlier than previously advised to Truman
- With no response from the Japanese government Niigata was targeted for Fat Man on 9 August
- This was a much riskier operation as the bomb had to be "primed" before take off because of its complexity
- The cloud and smoke cover was too great at Niigata so the attack was diverted to Nagasaki, the only feasible alternative with fuel running low
- The bomb was let go hastily and not quite on target
- An estimated 35,000–40,000 people were killed and 60,000 injured





The end game (5)

- The next bomb was expected to be delivered on 19 August with three more in September and a further three in October
- On 10 August, Truman secretly requested that additional atomic bombs not be dropped on Japan without his express authority but "normal" air raids continued
- The Japanese cabinet was undecided being split evenly between war and peace factions
- Secretary of State Byrnes crafted a note to be sent in secret to the Japanese subtly resolving the ambiguity over the future of the Emperor while not appearing to be compromising on the Potsdam Declaration
- *"From the moment of surrender, the authority of the Emperor shall be subject to the Supreme Commander of the Allied Powers ... (The Emperor) shall issue his commands to all the Japanese military, navy and air authorities and to all the forces under their control wherever located to cease active operations and to surrender their arms ... The ultimate form of government of Japan shall ... be established by the freely expressed will of the Japanese people."*

The end game (6)

- Finally, Hirohito indicated to the cabinet that immediate surrender was his preferred position and he would record messages for broadcasting to the Japanese people and to the armed forces
- The militarists in cabinet could not disagree with Emperor
- But junior officers attempted a coup to prevent the broadcasts going ahead but it rapidly fell apart
- 15 August the Japanese advised their acceptance of Byrnes note and Hirohito's address was broadcast in which he announced that Japan had decided to end the war
- *"... But now the war has lasted for nearly four years. Despite the best that has been done by everyone ... the war situation has developed not necessarily to Japan's advantage..."*
- *Moreover, the enemy has begun to employ a new and most cruel bomb, the power of which to do damage is, indeed, incalculable, taking the toll of many innocent lives..."*
- 17 August a shorter address was broadcast to the armed forces, in which he did not mention the bombs but did mention the Soviet Union's entry to the war

Should the bombs have been dropped?

- A visit to the memorial in Hiroshima is very moving
- The impact on the civilian population was frightening, particularly the effects of radiation
- Yet that doesn't mean that the decision to drop the bombs was wrong
- The decision cannot be considered in isolation
- It was part of a broader context of the state of the war in 1945
- The questions really should be: were there any better alternatives, and better in what sense?
- The key arguments that have been made against dropping the bombs are:
 1. *They were militarily unnecessary*
 2. *Their use on civilians was immoral, a war crime, or state terrorism*
 3. *The second bomb was totally unnecessary and therefore definitely immoral*

The situation facing civilians in Asia

- In Japan civilians were already facing starvation and constant bombing raids on cities including firebombing
- In Vietnam there was ongoing mass famine as result of the Japanese occupation that had already killed in excess of a million people
- In most occupied countries, civilians were subject to forced labour under brutal conditions with high death rates
- In China, the treatment of civilians was the worst of any
- Based on actual numbers of civilian deaths up to that date, it has been estimated that up to 250,000 people, mostly Asian, would have died for each month the war continued

The situation facing POWs

- For the Allies, there were genuine concerns about the potential for mass executions in POW camps throughout the occupied territories, in the event of a gradual collapse of Japanese control
- August 1, 1944, the Japanese War Ministry had ordered the execution of Allied POWs, "when an uprising of large numbers cannot be suppressed without the use of firearms" or when the POW camp was in the combat zone, in fear that "escapees from the camp may turn into a hostile fighting force"

Military alternatives

- Invasion had been more or less ruled out by this time because of the certainty of massive casualties to invasion forces, but the civilian casualties would have been even greater given the experience of the fighting in the islands
- The most practical alternative was to continue the blockade along with the bombing
- It has been argued that the Japanese would have had no choice but to surrender unconditionally no later than the end of 1945
- But, given the fanaticism of the militarists there is no guarantee of this
- They are on record as saying that Japan should fight to the last man
- For either of these alternatives, the civilian casualties in Japan and elsewhere in Asia *for every month that the war continued* would have been many times greater than those of Hiroshima and Nagasaki combined

An immoral action?

- Given the prolonged horrors that the war brought to the civilian populations of Europe and Asia, it is difficult to single out the atomic bombs as having delivered a uniquely horrible way of killing people
- To argue that inflicting prolonged mass starvation on the Japanese people, as the blockade was already doing, would have been somehow more humane, a better choice, runs counter to the evidence
- Similarly, the deaths and injuries inflicted on civilians by conventional bombing and particularly firebombing were as appalling as starvation or the atomic bombs
- To have condemned the civilians of Asia to a prolonged occupation would have been even worse since they were not the enemy
- Bringing the war to a rapid close using all the tools available was the least worse alternative

Did the bombs end the war or was it the invasion of Manchuria by the Soviet army?

- It was both
- There is no certainty that Stalin would have honoured his commitment to join the war at the time he said he would, given the many promises that he had reneged on previously
- The invasion of Manchuria was brought forward as soon he heard that the bomb had been dropped on Hiroshima
- Certainly, that killed off the naive hope that the Japanese government had of Soviet mediation on their behalf

Shouldn't there have been a demonstration of the bomb with a warning?

- Given the lack of understanding, the denial and the dithering shown by the Japanese government after Hiroshima, it is unlikely that a demonstration would have led to the government agreeing to an unconditional surrender
- The Japanese government had not yet reached a position where it could see no alternative to surrender
- There were also risks:
 - The possibility of the bomb not working which would have destroyed the credibility of the threat
 - The possibility that POWs and civilians would be deliberately moved into the drop zone

Was it necessary to drop the bomb on Nagasaki so quickly after the first?

- Probably yes
- As there were only 2 bombs available at the time, it was appropriate for the US to create the impression that they could keep on dropping them
- It also prevented the Japanese government from explaining Hiroshima away as a natural catastrophe as they had already tried
- A captured US airman, who knew nothing at all about the program, under torture, had wildly stated that the US had 100 such bombs and Tokyo and Kyoto would be next
- Hiroshima might have been seen as a once off but, after Nagasaki, these fanciful numbers became a believable threat and were even cited by the Minister for War
- There can be little doubt that the sequence of events from 6 to 9 August brought the Emperor to his decision that the war should end immediately



*"War is cruelty; and
you cannot refine it"*
William Sherman
1864