DIIS REPORT

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THE MARSHAL'S BATON
THERE IS NO BOMB,
THERE WAS NO BOMB,
THEY WERE NOT LOOKING FOR A BOMB

Svend Aage Christensen

DIIS REPORT 2009:18

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Danish Institute for International Studies, DIIS
Strandgade 56, DK-1401 Copenhagen, Denmark
Ph: +45 32 69 87 87
Fax: +45 32 69 87 00
E-mail: diis@diis.dk
Web: www.diis.dk

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Svend Aage Christensen, Senior Researcher, DIIS.

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Director's Preface

When I received the Foreign Minister's request for an investigation into the Thule accident and the underlying documentary evidence, I asked senior researcher Svend Aage Christensen, coordinator of a major research effort in 1996-97 on 'Greenland During the Cold War: Danish and American Security Policy 1945-68' to investigate the matter.

I am pleased to present the result of the investigation in this report.

Nanna Hvidt
Director

Author's Preface

I would like to thank my research assistant, Ms. Gry Thomasen, MA, for her excellent support in the creation of this report. She has screened the sources with a keen eye, made excerpts for the document database, found valuable materials in the Danish archives, and provided daily inspiration.

I would also like to express my gratitude to those colleagues and experts, in Denmark and abroad, who have generously offered me their time and advice.

Svend Aage Christensen

1. Introduction

Why this report?

In a letter dated 6 January 2009, the Danish foreign minister, Per Stig Møller, asked DIIS to draw up a report based on the documentary evidence concerning the 1968 crash of a B-52 bomber a few miles from Thule Air Base in northwestern Greenland. The B-52 had four hydrogen bombs on board. For more than four decades, the official American and Danish explanations have consistently stated that all four nuclear weapons were destroyed in the accident.

The foreign minister's initiative was caused by a debate in the Parliament (Folketing) over some programmes and articles carried by the BBC on November 10 and 11, 2008. Seven years earlier, in 2001, the BBC journalist Gordon Corera had received 348 documents on the Thule accident from the US Department of Energy's (DOE) archival facility in Las Vegas.

Gordon Corera is a security correspondent for BBC News. He covers counter-terrorism, counter-proliferation and international security issues for BBC TV, Radio and Online. He has written extensively on the British and American intelligence community and has worked as a foreign affairs reporter for Britain's *Today* show. He is the author of a very good article, 'The Need for Context: The Complexities of Foreign Reporting'. An Old Gower, he continued his education at Oxford and Harvard universities and joined the BBC in 1997. This set of circumstances looked promising: a journalist with excellent training and experience, 348 documents, and seven years of reflection and research.

Unfortunately, the result did not quite live up to expectations. It is fair to ask whether, in Corera's view, the historical 'truth' is confined exclusively to English language sources. The main assertions in the article were that only three of the four nuclear weapons on board the B-52 could be accounted for, thus leaving open the possibility that there was still a nuclear weapon on the bottom of the sea in the bay outside Thule, and that the Americans had withheld information about the real purpose of a bottom survey done by a submersible in the summer of 1968, namely that it was looking for the parts of a nuclear weapon.

The first assertion about the bomb was old news that had been presented in Danish media since 1987 and in a new version in 2000. The 2000 version was based on

documents that had been declassified in May 1988, together with another document declassified in November 1995. The second assertion about information having been withheld concerning the true meaning of the bottom survey could be called new news as far as extensive media coverage is concerned, but it was based on an old, well-known document that was declassified in February 1991 and was among the collection of 317 documents mentioned below. There is no evidence that Corera has been working in the Danish archives or that he has tried to verify or nuance his assertion that Denmark was kept in the dark about the purpose of the underwater operation.

The foreign minister's specific question to DIIS was whether the 348 documents (or approximately 2,000 pages) obtained by Corera in 2001 contained decisive new information as compared with 317 documents declassified by the Department of Energy (DOE) from 1986 onwards and released as announced by DOE on 15 September 1994. The Thule Radiation Victims Association had requested access to the documents, which were also handed over to the Danish government at its request.

The 317 documents of the 1994 release also form part of the 2001 release of 348 documents with only some variation. Although the 348 collection does contain a few important documents not found in the 317 collection, none of them have been used in Corera reports or articles. To elaborate a little, the assertions concerning the bomb in the BBC articles and programmes are identical with claims made by the Thule Workers' Association in August 2000, which were widely circulated in the Danish and international media at the time, for instance, in the Danish daily *Jyllands-Posten* for 12 August 2000 (J-P 12.8.2000), and by the BBC on 13 August 2000 (BBC News 13.8.2000).

BBC Radio World Service even went one step further by claiming that: 'A BBC investigation ... has for the first time proved that rumours of a lost bomb are true' (BBC World 2008). No small feat. 'All his geese are swans', as the saying goes. BBC Two's Newsnight was on the same track, explaining that 'The US abandoned a nuclear weapon beneath the ice in northern Greenland following a crash in 1968, a BBC investigation has found' (BBC Two 2008).

Allegations about a 'missing bomb' have a long history. For instance, in December 1987 Danish media reports raised the question once again. The Danish foreign minister explained that the U.S. Air Force had never rejected the possibility that parts of one or several bombs could have fallen through the ice, but that it was beyond

doubt that the four bombs had been destroyed in the crash. He added that the sea bottom surveys performed in August 1968 by the submersible Star III had produced aircraft debris but no bombs.

Closely interwoven with that topic has been the plutonium balance sheet, that is the balance between the amounts of plutonium in the bombs and the plutonium that was dispersed as a result of the accident. In September 1988, the Danish prime minister answered questions in Parliament on this issue.

The similarity of the assertions about one of the bombs is not surprising, given that they rest upon nearly identical documentary evidence. In both 2000 and 2008, the media were using almost the same documents and were interpreting a limited and identical number of passages in a few of the 348 documents.

It should be mentioned, though, that there was one significant difference. In the 2008 BBC reports, a number of US officials or scientists who dealt with the aftermath of the accident back in 1968 had been tracked down by the BBC journalist and apparently confirmed some of the documentary information.

One was William H. Chambers, a former deputy associate director and nuclear weapons designer at the Los Alamos National Laboratory, who once ran a team dealing with accidents, including the Thule crash (see doc. 107026 for a glimpse of his role). 'There was disappointment in what you might call a failure to return all of the components,' he told the BBC, explaining the logic behind the decision to abandon the search. 'It would be very difficult for anyone else to recover classified pieces if we couldn't find them' (BBC News 2008; BBC Two 2008).

According to Chambers, the view was that no one else would be able to find these sensitive items covertly and that the radioactive material would dissolve in such a large body of water, making it harmless. The BBC article also states that other officials who have seen classified files on the accident confirmed that a weapon was abandoned. The Pentagon declined to comment on the investigation, referring to previous official studies of the incident.

This account raises some questions. The article claims that unnamed sources have 'confirmed the abandonment of a weapon'. The latter may, of course, be a faithful quotation of what the unnamed sources have said, but their evidence does not confirm what Chambers had said, since the two accounts are speaking of different things,

Chambers about 'components' and 'classified pieces', the anonymous sources about 'a weapon'.

One can also surmise that Chambers may have had different scenarios in mind, one in which the active material was preserved in one piece, and another in which the material had been split into particles or fragments.

It seems reasonable to suggest that Chambers was holding two possibilities open in his statement, the first being that the 'classified pieces' were intact but had not been found, the second that they had been split into particles or had crumbled and were non-existent as 'pieces'. To repeat, what the anonymous sources 'confirm' in apparently saying that 'a weapon had been abandoned' does not provide confirmation of what Chambers had said, but constitutes a separate and less concrete form of testimony.

The BBC article continues: 'But the crash, clear-up and mystery of the lost bomb have continued to haunt those involved at the time – and those who live in the region now – with continued concerns over the environmental and health impact of the events of that day in 1968.' Whatever the intention behind this concluding remark, it might easily be read as an *argumentum ad misericordiam* meant to support the two sensational main assertions.

We have no idea why it took the BBC journalist seven years to produce his programme and articles after he had received the batch of 348 documents from DOE. Whatever the reason, there is no trace in his articles that it was the study of these documents that kept him busy for so long. The most interesting thing about his account is not what it says about Thule, but that once this under-researched story had been aired, it was spread to thousands of media worldwide in a matter of hours. You name them, they all have it – from the Rachel Maddow Show to Tageszeitung to Bogotá: 'Estados Unidos abandonó un arma nuclear debajo del hielo, en el norte de Groenlandia, a raíz de un accidente aéreo ocurrido en 1968, como demostró una investigación de la BBC.'

In the New York Times flagship blog Lede, one of the staff correspondents, assistant to the editor of the New York Times, Carla Baranauckas, who received her M.S. at Columbia's Graduate School of Journalism, cited the Chambers interview as follows: 'He said that there was disappointment when the search was called off, but that the assumption at the time was that if the United States couldn't find that H-bomb, no one else would be able to find it either.' Chambers had not said a word about a bomb.

Nuclear proliferation had finally reached the editorial offices of the New York Times – perhaps a new target for IAEA inspections.

Lede's unofficial motto comes from T.S. Eliot: 'Immature poets imitate; mature poets steal; bad poets deface what they take, and good poets make it into something better, or at least something different.' The reader might speculate whether it would be a logical fallacy to conclude that Ms. Baranauckas is a good poet.

In the midst of the international media blitz, only Hans M. Kristensen, a project director with the Federation of American Scientists, took a different line, telling the Italian channel Panorama that the documents he had seen showed that the fourth bomb had been destroyed like the three others ['Le carte che ho potuto studiare io dicevano che anche la quarta bomba andò distrutta, come le altre tre'] (Kristensen 2008).

In a way, this summary is already close to providing an answer to the foreign minister's question. No new assertions about a missing bomb were made in 2008, and the documentary evidence was much the same as that released by DOE in 1994, which has been available in Copenhagen since then and was also used in the Jyllands-Posten's 2000 article. On this basis, one could argue that there would be nothing to add to the answers provided by the Danish and American authorities in 1995 and 2000.

Close, but not close enough to provide a fair answer to the minister's question. Any such reading of the minister's letter would be highly formalistic. The primary reason for this is that an impartial professional analysis of the documents has never been undertaken. In the absence of such an analysis, it would seem useful to provide at least some elements of an impartial analysis of the released documents and thus be in a position to comment on the official explanations and the assumptions presented in the media in, for instance, 1987, 1988, 2000 and 2008.

It may come as a surprise to many that no such impartial professional analysis was ever undertaken. Probably, the explanation is that the focus on matters related to Thule and the US presence there has changed over the years. At one time, the focus was the dislocation of the Uummannaq settlement in 1953 in connection with the construction of an air defence system for the base, then it was health physics and radiation associated with the 1968 accident, and finally the international relations aspects of Thule Air Force Base as epitomized by the so-called H.C. Hansen document of 1957 (Hansen was the Danish prime minister at the time).

The latter story has been dealt with in a major two-volume study undertaken in 1996-97 by the Danish Institute of International Affairs (DUPI). Among many other things, it covers the prehistory and political aftermath of the 1968 accident. However, DUPI was not tasked with undertaking studies of what had happened to the bombs. A fifty-page English summary of the 1997 DUPI Report is available: 'Greenland during the Cold War: Danish and American Security Policy 1945-68'.

At least since the turn of the millennium, and indeed for longer than that, the focus has been on questions of radiation and health physics. For the moment, this appears to be a relevant and desirable research priority.

What DIIS can do

DIIS can conduct historical research on the basis of the available documents, subject them to analytical examination and try to extract evidence from them when they appear to be silent, or when particular words, lines or paragraphs have been declared exempt from declassification and have accordingly been erased or obliterated by the releasing agency.

To our knowledge, this is the first time that these documents have been subjected to systematic examination by a historian having the fate of the weapons as the research focus. As already mentioned, the DUPI Report of 1997 had no such focus and was based on a quite different collection of sources procured by DUPI itself from a wide range of U.S. and Danish archives. That report mainly covered the preceding years, and as far as the 1968 events are concerned, it dealt almost exclusively with the diplomatic aftermath of the crash.

This Danish research effort was clearly reflected at a later stage in Vol. XII of Foreign Relations of the United States, 1964-1968 (FRUS). The FRUS series presents the official documentary historical record of major U.S. foreign-policy decisions and significant diplomatic activity. The series, produced by the State Department's Office of the Historian, began in 1861 and now comprises more than 350 individual volumes.

DIIS can do what historians are trained to do, namely try to reconstruct and understand a chain of events in the past. However, DIIS cannot investigate the documents with the eyes of engineers, physicists, medical doctors or similar professionals.

DIIS has no expertise in nuclear physics, nuclear radiation, health physics etc. Accordingly, we will stay clear of these fields and deal only with that one corner of these events which can be defined as the fate of the nuclear weapons. However, this is not an isolated corner, but one with implications for the other aspects of this complex of problems.

Some initial observations

As already mentioned, all down the years since 1968, the official version of what happened to the four nuclear weapons has been that they were destroyed in the crash. On several counts, the released documents seem to support the official explanation at first glance.

For instance, in an early report of 27 January 1968 – only six days after the crash – the SAC Disaster Control Team reported that 'based on the serially numbered components found to date, there is convincing evidence that at least three separate WH [warhead] H.E. [high explosives] detonated high order on or above the surface of the ice. This conclusion is based on the location of the four weapon parapacks [packs with parachutes for the weapons], three tritium bottles, and portions of three separate weapon secondaries' (doc. 107132). This document was declassified as early as 1988.

We have chosen this early quotation on purpose in order not to take the suspense completely out of the narrative of the present investigation. It still leaves room for some doubt as to the fate of the fourth bomb.

This initial observation, however, will not distract us from the main task. As explained below, our purpose in this report is to undertake an impartial assessment of the events on the basis of the released documents. With this in mind, we will keep the door open for any explanations that can reasonably be supported by the documents.

What we expect to accomplish

We hope that a thorough examination of the American documents will provide a better understanding of the complexities met with by the historian, whose task it is to decipher the excised documents, where information that may be of importance for the full understanding of the events is often deleted.

We will do our best to establish the nature of the excised parts of the documents in order to try and provide a coherent picture of the reason the deletions were made.

We are not convinced that it will be possible to provide definitive answers to the questions that have attracted the interest of the public on the basis of sanitized documents. Nonetheless, we hope that even some less definitive reflections on these questions may prove to be of some value. If we are able to accomplish any more, that would be a pleasant surprise.

Before we turn to the detailed investigation, it should be mentioned that some of the basic facts about the aircraft, the bombs, the site, the sea bottom and the submersible are presented in fact boxes in the appendices.

Furthermore, a spreadsheet with basic data regarding all 348 documents in the collection is available for download on the DIIS website. It contains excerpts from some of the documents, and those documents that we have found to be of special interest for the purposes of this report have been colour coded. The documents can be sorted in various ways: by author/issuing agency, by date of issue, in some cases even by hour and minute, by date of declassification etc. On the website, a collection of photographs from the dives of the American submersible Star III in Bylot Sound outside Thule can also be found.

2. Plan of the investigation

Based on the assumption that the interpretation of what happened to the nuclear weapons is likely to have changed during the long search and clean-up operation, we will conduct a chronologically organized analysis of some of the key documents. This will serve as a simple first layer of protection against the confusion that could easily result from reading the documents haphazardly.

We also hope that a chronologically ordered survey will lead to insights into the development of the thinking of those involved in the operation in Thule.

After the chronological analysis, we will look for analogies by making a short excursion to the Palomares accident of 1966, which involved the same type of aircraft and weapons as in Thule two years later. Palomares is a coastal village in southeastern Spain.

We will then sum up what we have learned about the recovered weapons parts and provide some additional information and analysis from other sources. Next, we will recapitulate those observations that may be of relevance for the plutonium balance sheet.

The reader is therefore invited to join us on a short excursion through the sanitized documents in order to see whether they contain more information than has been thought up to now. Unfortunately, the many deletions in the documents have the inevitable consequence that quite a few conjectures will be necessary in the course of the analysis, for which we ask the reader's indulgence. We could have spent several months longer trying to solve the puzzles in the sanitized documents, but that would have meant taxing the readers' patience even more than we have done already.

Having collected the bits and pieces together, we will finally assess the evidence in a systematic manner and then present the conclusions of the report.

The scope of the report is limited in the sense that it is primarily based on the 348 collection, that is, U.S. documents that in many cases have been declassified for nearly two decades, but in addition a few documents from Danish and other archives will be considered. The report does, however, benefit from the few documents that are new in the 348 collection as compared to the 317 collection, as well as to a lesser

degree some of the documents in a collection handed over to the Danish government in 1988 and declassified in 1994.

Finally, a few remarks on terminology might be in place. The words 'deletion' and 'excision' are used interchangeably. A 'sanitized' document is one in which some parts have been 'deleted' or 'excised', represented by black bars or white holes in the remaining text. 'Redacted' is another word in the jargon for 'sanitized'. A 'partially redacted' document can be found to be 'releasable'. The deleted parts can be characterized as 'withheld' or 'exempt from declassification'. The same happens to whole documents that can then be represented in the publicly accessible archive folders by a 'withdrawal sheet' loosely identifying the 'withheld' document.

Just because a document is 'declassified' does not mean it is automatically accessible. First it has to undergo a 'release' process that can involve reviewing information on the basis of privacy, law enforcement, and other considerations. As a more general remark, not aimed at any specific countries, some classified documents may be completely hidden for the historian's eye in document collections that he will not even suspect exist or in archive holdings with outlandish names that have been deliberately chosen to mask their real contents.

3. Chronological analysis of key documents

The documents in the collection are highly repetitious, as they reflect the different phases of communication between a large number of agents and agencies in the bureaucratic chain of command. In this sense, the documents are like a nest of Chinese boxes. The starting point of much of the subsequent correspondence would be General Hunziker's Strategic Air Command (SAC) Disaster Control Team, which after the accident was flown in to Thule on short notice from SAC Headquarters in Omaha, Nebraska.

Mobilization after the accident involved personnel from the Danish authorities and over 70 U.S. agencies, including elements of the Department of Defense, Atomic Energy Commission (AEC), State Department, Los Alamos Scientific Laboratory and Lawrence Radiation Laboratory. Reports and briefs were regularly prepared for the Chief and Vice Chief of Staff of the Air Force (CSAF), CINC SAC, the Secretary of the Air Force, the Joint Chiefs of Staff (JCS), and the Secretary of Defense.

Some of the best and clearest summaries of the information sent forward in the chain of command were written by the office of Brigadier General Edward B. Giller, Director of the Department of Military Applications in the Atomic Energy Commission. His memoranda were sent to the chairman and commissioners of the AEC. The chairman was the chemist, Glenn Theodore Seaborg, who had shared a 1951 Nobel Prize for the discovery of plutonium in 1941.

To begin with, we will devote the first pages of the chronological survey to some microanalysis of the documents that cover roughly the first ten days after the accident. This is the period in which the most significant weapon finds are concentrated. We should not expect this to add significantly to what is already known about the accident, but nonetheless it may provide some insights into the nature of the secrecy surrounding the event, the sorts of information the excisions are intended to hide, the comprehensiveness of the security reviews, and the effectiveness or ineffectiveness of the exemptions and excisions in guarding these supposed secrets.

Later in the chronological survey, we will focus on groups of documents dealing with specific aspects of the operation, such as the recovery of fissile material from the secondaries, the underwater operation, and discussions among decision-makers in Copenhagen and Washington.

22 January 1968, doc. 107145
This document is a status report for the accident in the form of a memorandum from Brigadier General Edward B. Giller, head of the Department for Military Applications (DMA) at the United States Atomic Energy Commission (AEC), to the Chairman of the AEC, Seaborg, and his commissioners. The document was declassified in 1988 and is identical with document 75943 apart from a difference in redaction.

Giller wrote ten such status reports over the period up to 10 September 1968. Generally, Giller's status reports give a convenient overview of the events as they unfolded in the United States and Greenland. They are easier to work with than the many scattered telegrams.

This is the first day after the crash. The memorandum states that there have been no reports of any explosions resulting from the accident, and the evaluation was that the weapons had remained fixed to the bomb racks and sunk with the fuselage. However, at the time of reporting, the location and condition of the four weapons was still unknown.

injuries suffered in the bailout and his body has been recovered.

DELETED

The present evaluation is that the weapons remained fixed to the aircraft bomb racks and sank with the fuselage. At the present time, however, the location and condition of the four weapons is still unknown. There have been no reports of any explosions resulting from the accident, only the fire. There have been no reports of any radiological contamination.

Taking into consideration the darkness and the cold, one can hardly expect the first reports about the accident to be precise. In fact, this report was already contradicted the next day. Still, what the document conveys seems to be that no detonations of the high explosive in the weapons had been sighted or heard, and that the author was already aware at this time that a hole had been made in the ice.

In the duplicate version of the document, doc. 75943, which had been declassified two years earlier, in 1986, the first three and a half lines of the last paragraph of the above quote have been excised. This is the first but not the last inconsistency of redaction that we will find in the documents.

Ahead of the last paragraph, one or two lines have been deleted in both redactions. The fuller of the two versions allows us to surmise that these lines contain a description of the four thermonuclear weapons, known to have been of type Mark 28, the same as in the accident two years earlier in Palomares, on the southeastern coast of Spain.

23 January, 1968, doc. 107144
A preliminary report from the SAC Disaster Control Team has a list of weapons, fuses and chutes involved (with the precise identifications deleted). It also states that there were indications that one or more weapons went high explosive (HE) high order, as well as that parts might have gone right through the ice.

The idea of a HE high-order detonation may reflect the fact, that in this early phase of the search, perhaps none or only very few parts of the weapons had been found. At this point, a high-order detonation plus a hole in the ice might be one way of explaining the possibly meagre results of the initial searches for weapon debris.

On January 25, at a meeting in the Danish Atomic Energy Commission in Strandgade in Copenhagen, Dr Carl Walske, Assistant to the Secretary of Defense for Atomic Energy, gave his version of what was known about the bombs at this early stage.

According to the Danish minutes, he said that 'it was possible that the high explosives in one or more of the weapons had detonated. [...] Available information indicated that one of the bombs had detonated and that this had led to plutonium contamination. [...] None of the four bombs had been found, but the four parapacks that are fastened to the bombs had all been found. [...] Three of the parachutes showed no signs of explosion or fire, while one which had been found approximately 300 metres from the impact point (the others were closer) had clear marks of fire or explosion.'

'Thus, one could deduce that one bomb had been damaged, while the three others were possibly intact on the ice, in the ice or on the sea bottom; the possibility that one or more of the latter bombs had been damaged as well could not be ruled out; pieces of metal, maybe from a bomb, had been found near the impact point.' (AEK 26/1 1968).

25 January 1968, doc. 107138
A telegram from the SAC Disaster Control Team raises a number of questions, among them: 'If some weapon components are on the bottom of the bay at approximately 625 feet of water, how can they be detected and removed?'

25 January 1968, doc. 107139
The SAC Disaster Control Team stated its belief that an underwater effort might be required. However, on the very day of the report and the next day weapons parts began to be recovered on the surface, and ideas about an underwater search were temporarily laid aside for the more pressing needs of the surface operation.

26 January, 1968, doc. 107137
The clip below is from a cable sent by the SAC Disaster Control Team about its operations on January 25.

We learn that 'two objects, approx 24 inches (61 cm) long and 10 inches (25 cm) wide, located 2 and 1 slant 2 miles south southwest of impact point and approximately 300 yards (275 m) apart, have been tentatively identified'. The whole paragraph is apparently about weapon components. We learn from other documents that the two objects had been tentatively identified as secondary cases and that they had not been identified with any specific weapon (doc. 107121). Since they were identical in size and had been found 300 yards apart, we can assume that they are from different weapons.

AREA ALSO INDICATED 2,000,000 CPM OR GREATER. 3. TWO OBJECTS, APPROX
24 INCHES LONG AND 10 INCHES WIDE, LOCATED 2 AND 1 SLANT 2 MILES
SOUTH SOUTHWEST OF IMPACT POINT AND APPROX 300 YARDS APART, HAVE BEEN
TENTATIVELY IDENTIFIED DELETED
TWO BADLY DEFORMED T BOTTLES, LESS VALVES, DELETED
WERE FOUND IDENTIFIED BY SERIAL NUMBER. SEARCH IS CONTINUING
26 JAN. SEARCHERS ARE NOW USING COLEMAN LANTERN. 4. THE SECOND

We may ask what 'tentatively identified' means. This is hidden by the excision. Does this indicate doubt as to what type of object it was? Or does it mean that the serial numbers were not visible or maybe had been damaged and were hard to read? Maybe not the former, if we assume that the two objects were parts of secondaries. If so, they would probably be recognizable from their shape. It is significant that the location indicated is consistent with the locations of secondary parts on a sketch of the crash site to be presented later (Chapter 5).

We have therefore already disclosed the identity of the finds. If we thought that this would remain hidden from us, we were mistaken. Because of inconsistent

redacting, the identity of the objects is revealed in, for instance, doc. 107132 of 27 January, which summarises the finds of the previous days (see below), while a few days later, in doc. 107121, we are given the answers to some of our conjectures once again (see below under 30 January). Furthermore, in his report #4, doc. 107128, CSAF says that these finds are significant.

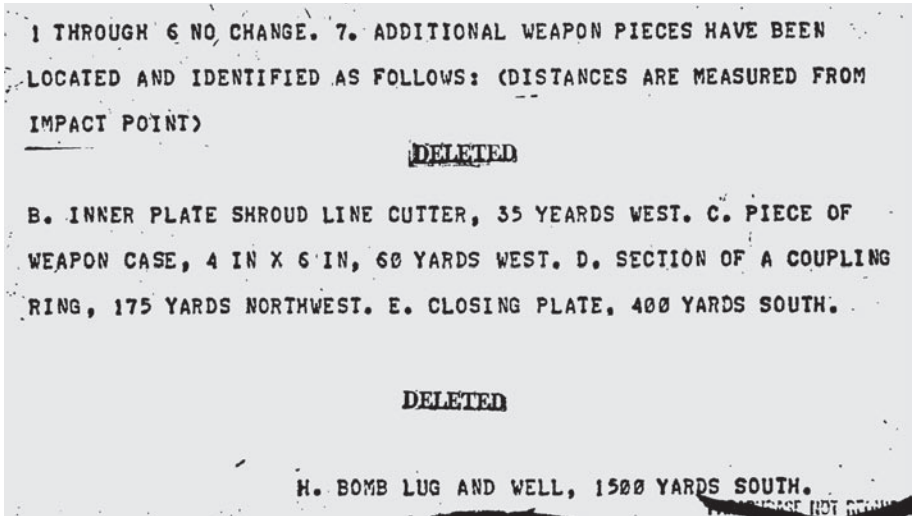
Two badly deformed T bottles were also found on this occasion. T bottles are sometimes called 'reservoirs' in the documents. They are containers that hold tritium, which is used to boost the yield in the primary stage of a nuclear weapon. The fact that they were found separated from other parts of the weapons is yet another clear indication that some of the weapons had broken up. For ease of maintenance, the reservoirs are placed at the tail end of the bomb, outside the physics package.

Finally there is the deleted part after '... less valves'. This half line hardly contains information about the location of the T bottles. It is not likely that such information should be excised when it is not concealed two lines earlier. That leaves us with two options. Either something else is missing, or something else was found together with the bottles, and was presumably identified by serial number alongside the T bottles.

The excised part might also contain a qualification about the valves of the tritium bottles, since a valve is mentioned in a subsequent memorandum, doc. 107121. We cannot know. Still, if something else was found, we can say with near certainty that the excised part is not about parapacks. Parapacks are mentioned in several other documents, and information about them is not kept classified.

27 January 1968, doc. 107130

In his report #3 to JCS, CSAF provides information about newly recovered weapon parts, litra a. through h. We have moved one step up the bureaucratic ladder where CSAF is summarizing and commenting on the finds that have already been reported by the SAC Disaster Control Team. The parts in litra a., f. and g. have been deleted from the list, but we learn what they are from a comparison with other documents. These are probably the more interesting finds. That, at least, is what CSAF thinks since the next day in report #4 he calls them 'significant finds'.



1 THROUGH 6 NO CHANGE. 7. ADDITIONAL WEAPON PIECES HAVE BEEN LOCATED AND IDENTIFIED AS FOLLOWS: (DISTANCES ARE MEASURED FROM IMPACT POINT)

DELETED

B. INNER PLATE SHROUD LINE CUTTER, 35 YEARDS WEST. C. PIECE OF WEAPON CASE, 4 IN X 6 IN, 60 YARDS WEST. D. SECTION OF A COUPLING RING, 175 YARDS NORTHWEST. E. CLOSING PLATE, 400 YARDS SOUTH.

DELETED

H. BOMB LUG AND WELL, 1500 YARDS SOUTH.

The ensemble of recovered parts now leads CSAF to inform JCS that all weapons are thought to have broken-up to varying degrees. Furthermore, evidence so far tends to indicate a low-order high explosive (HE) detonation [words deleted], but no firm conclusions have been drawn.

We are now on day 5 after the accident, and a somewhat more precise picture of the fate of the weapons begins to emerge, although firm conclusions cannot be drawn. In contrast to doc. 107144 of 23 January, the investigators now find indications of low-order rather than high-order explosions of the high explosive (HE) in the weapons (cf. fact box). Because of the deleted words, we cannot be sure whether this assessment covers all the weapons or only some of them. The wording 'evidence so far tended to indicate' may well mean that only some of the weapons were covered.

The high explosives mentioned here are the HE charges in the primary parts of the weapons. We have only one source for the amount of HE in each of the primaries, which says it was 250 kg (Notits 5/2 1968). Whether this amount is correct we do not know.

Anyway, one ton of HE, together with more than 100 tonnes of jet fuel, would seem to go a long way in explaining the total degree of destruction of the aircraft. Professor Kofoed-Hansen reported that the aircraft had been shattered into millions of pieces across an area of 5-10 square kilometres (Notits 5/2 1968).

The wording 'broken up to varying degrees', taken together with only a 'low order' detonation in the primaries, could indicate that some larger portions of the secondary parts of the weapons had been found on the ice, together with smaller parts as well (107130).

If we assume that a high-order detonation would do more damage to the secondaries than a low-order detonation of maybe only some of the HE charges in the primaries, the reason for the changed assessment of the character of the HE detonation might be that some relatively well-preserved components of the secondaries had been found on the ice since the first assessment. Obviously, recovery of some of the other pieces may also have supported the new assessment.

Nothing is said about finds of primaries or primary parts. Instead we learn about their fate in the wording 'low-order' detonation. The suspected low-order detonation in the primaries would explain the 'omission' of any mentioning of primaries, as there may not have been any vital pieces of primaries to report about, at least at the time this report was written.

The primaries with the HE were more exposed to destruction than the secondaries. Nowhere in the documents have we observed any discussion of the possibility that some weapons could have gone high order while others went low order. Perhaps one should keep open the possibility that the bomb with serial number SN 78252 had gone high order and thus been more badly damaged than the three other weapons.

The type of contamination on the site may have provided the investigators with another clue for their assessment. They knew the composition of the pit in the primary, which contained both highly enriched uranium and plutonium. They also knew the state and mass of the secondaries found up to the time of writing the report. We suppose that the secondaries contained no plutonium, only uranium. Substantial amounts of the uranium from the secondaries were recovered during the clean-up operation. We will return to the question of the composition of the fissile core of the secondaries in our survey of the February operations, as well as later on.

27 January 1968, doc. 107132

Additional weapon components were found on 26 January. A cable from the SAC Disaster Control Team speaks with a higher degree of certainty than the preceding document. It states that, 'based on the serial numbers of the found components,

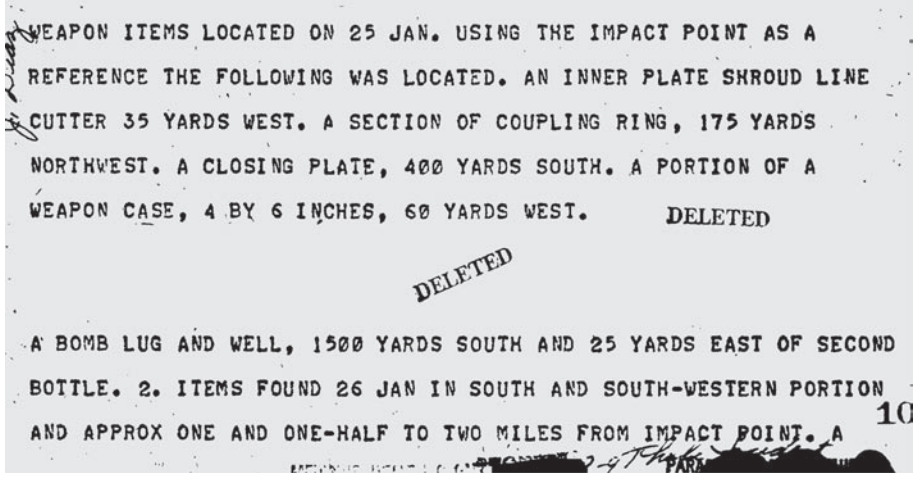
there is convincing evidence that at least three separate warheads HE detonated high order. [...] This conclusion is based on the location of the four weapon parapacks (parachute packages), three tritium bottles and portions of three separate weapon secondaries.' (107132). With these words, the discussion of low versus high order explosions was apparently settled in favour of high order, and the speculations on the basis of the preceding doc. 107130 may seem to have been in vain.

The first part of the clipping reports the finds of 25 January. It follows that the excised part is about the two secondary cases found 2 and 1 slant 2 miles S-SW of impact point and characterized as significant finds by CSAF (107128).

The second part summarizes the finds of 26 January. What do the excised lines represent here? From the document itself we learn that the finds were portions of secondaries. CSAF, in his report #4 the next day, tells us that the find consists of four more serially numbered weapons parts.

In the last paragraph of the clipping there is one deleted word. We suggest that the word 'segment' could be hidden behind the black bar. The segment took up most of the space in the secondaries.

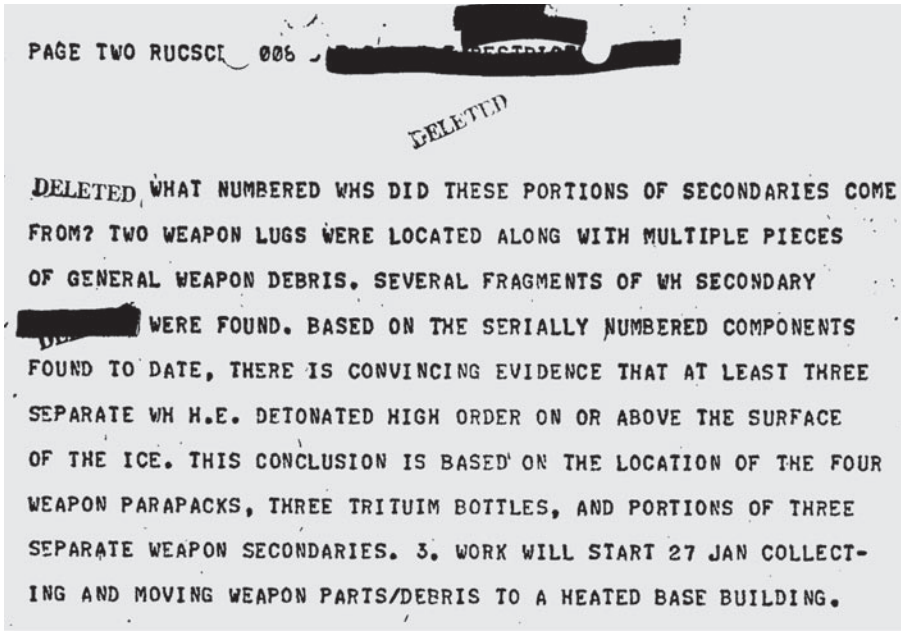
In other words, no parts had yet been identified with the fourth secondary. This was mentioned again in Giller's third status report of 2 February (doc. 318366, declassified in November 1995) and fourth status report of 23 February (doc. 318356, declassified in November 1995).



WEAPON ITEMS LOCATED ON 25 JAN. USING THE IMPACT POINT AS A REFERENCE THE FOLLOWING WAS LOCATED. AN INNER PLATE SHROUD LINE CUTTER 35 YARDS WEST. A SECTION OF COUPLING RING, 175 YARDS NORTHWEST. A CLOSING PLATE, 400 YARDS SOUTH. A PORTION OF A WEAPON CASE, 4 BY 6 INCHES, 60 YARDS WEST. DELETED

DELETED

A BOMB LUG AND WELL, 1500 YARDS SOUTH AND 25 YARDS EAST OF SECOND BOTTLE. 2. ITEMS FOUND 26 JAN IN SOUTH AND SOUTH-WESTERN PORTION AND APPROX ONE AND ONE-HALF TO TWO MILES FROM IMPACT POINT. A



PAGE TWO RUCSCI 006 [redacted]

DELETED

DELETED WHAT NUMBERED WHS DID THESE PORTIONS OF SECONDARIES COME FROM? TWO WEAPON LUGS WERE LOCATED ALONG WITH MULTIPLE PIECES OF GENERAL WEAPON DEBRIS. SEVERAL FRAGMENTS OF WH SECONDARY [redacted] WERE FOUND. BASED ON THE SERIALLY NUMBERED COMPONENTS FOUND TO DATE, THERE IS CONVINCING EVIDENCE THAT AT LEAST THREE SEPARATE WH H.E. DETONATED HIGH ORDER ON OR ABOVE THE SURFACE OF THE ICE. THIS CONCLUSION IS BASED ON THE LOCATION OF THE FOUR WEAPON PARAPACKS, THREE TRITUIM BOTTLES, AND PORTIONS OF THREE SEPARATE WEAPON SECONDARIES. 3. WORK WILL START 27 JAN COLLECTING AND MOVING WEAPON PARTS/DEBRIS TO A HEATED BASE BUILDING.

It should be noted that the present document, 107132, which mentions that no parts of the fourth secondary had been found in the early phase of the search, had already been declassified in 1988, more than 20 years ago. Thus, the difficulty of accounting for the secondary stage proper of the fourth weapon can hardly come as a surprise today.

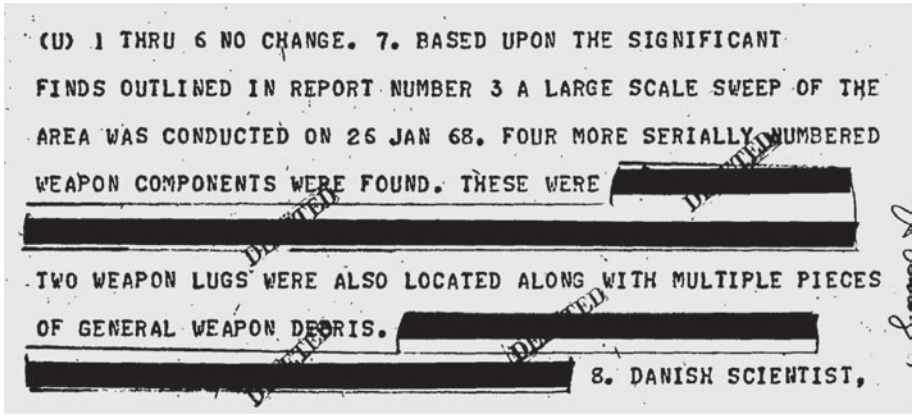
The official explanations could be considered somewhat stronger on the basis of the circumstantial evidence of the document. It is therefore appropriate to ask, if three bombs had apparently fared so badly, why not the fourth as well? This seems the most likely explanation. On the other hand, the document contains no trace of the fourth secondary. It might have disappeared undamaged through the hole in the ice. If that could be proved or made plausible, it would seriously undermine the official explanations.

27 January 1968, doc. 107133

This cable from CSAF to the SAC Disaster Control Team contains the answer to the question raised on 25 January about underwater operations. The most promising method for underwater reconnaissance, detection and the removal of objects would be the Navy's Curv Diving System. Curv had a radius of action of 500 to 600 feet at a depth of 600 to 700 feet when operated from a tether point on the surface

ice. It had been successfully used in recovering a bomb in the Mediterranean near Palomares in Spain two years earlier.

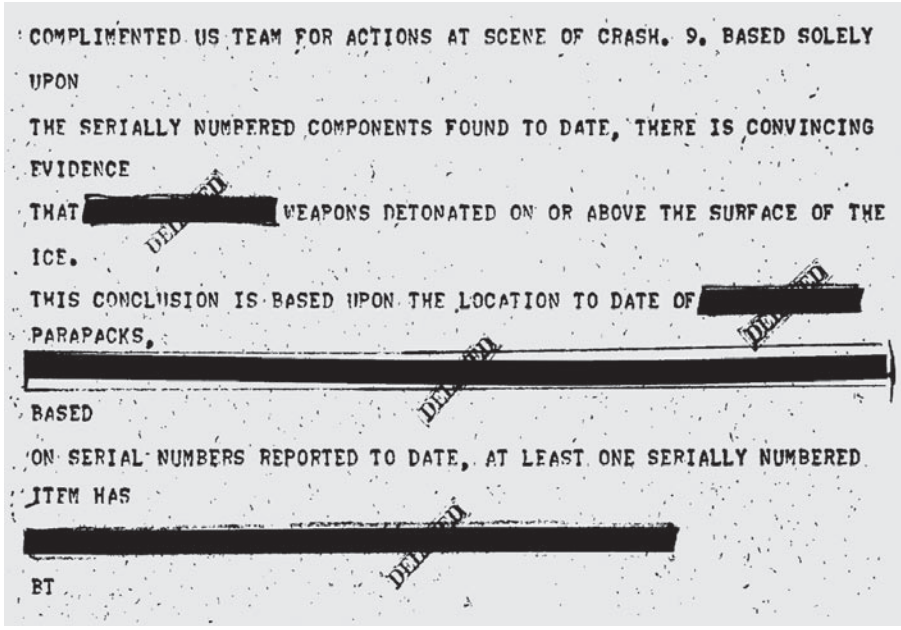
28 January 1968, doc. 107128
Below is report #4 from CSAF about yet another successful weapon recovery operation on 26 January.



(U) 1 THRU 6 NO CHANGE. 7. BASED UPON THE SIGNIFICANT FINDS OUTLINED IN REPORT NUMBER 3 A LARGE SCALE SWEEP OF THE AREA WAS CONDUCTED ON 26 JAN 68. FOUR MORE SERIALLY NUMBERED WEAPON COMPONENTS WERE FOUND. THESE WERE [redacted] TWO WEAPON LUGS WERE ALSO LOCATED ALONG WITH MULTIPLE PIECES OF GENERAL WEAPON DEBRIS. [redacted] 8. DANISH SCIENTIST,

In the morning, CSAF informs JCS that four serially numbered weapon components had also been found. The description of these four weapon components is deleted, and it is hardly possible to guess what they were on the basis of this document.

A little later, the document states the following:



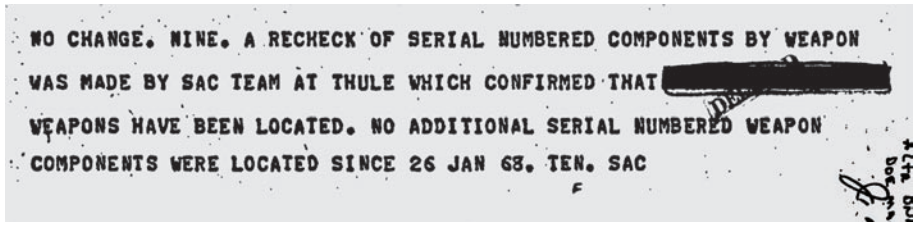
COMPLIMENTED US TEAM FOR ACTIONS AT SCENE OF CRASH. 9. BASED SOLELY UPON
THE SERIALLY NUMBERED COMPONENTS FOUND TO DATE, THERE IS CONVINCING EVIDENCE
THAT [redacted] WEAPONS DETONATED ON OR ABOVE THE SURFACE OF THE ICE.
THIS CONCLUSION IS BASED UPON THE LOCATION TO DATE OF [redacted]
PARAPACKS, [redacted]
BASED
ON SERIAL NUMBERS REPORTED TO DATE, AT LEAST ONE SERIALLY NUMBERED ITEM HAS [redacted]
BT

Based solely on the serial numbers on the components found to date, the document says that 'there is convincing evidence that [deleted] weapons detonated on or above the surface of the ice'. If this were all the information we had it would not be much, but what we have here is not impenetrable secretiveness, but rather an example of inconsistent redaction. In document 107132 above we have just seen what is behind the black bars in 107128: four parapacks, three tritium bottles and parts of three separate weapon secondaries.

Ironically, the secretive 107128 with its excessive excisions was declassified three years after the more transparent 107132.

28 January 1968, doc. 107129

In his report #5 of 28 January 1968, afternoon, CSAF informs JCS regarding confirmation that several weapons had been found. The excision means that we cannot know how many weapons had been found by then – meaning parts of weapons – only that not all four had been found. But again this is a result of inconsistent redaction. In document 107132 we have already seen what is hidden behind the black curtain: four parapacks, three tritium bottles and parts of three separate weapon secondaries.


NO CHANGE. NINE. A RECHECK OF SERIAL NUMBERED COMPONENTS BY WEAPON
WAS MADE BY SAC TEAM AT THULE WHICH CONFIRMED THAT [redacted]
WEAPONS HAVE BEEN LOCATED. NO ADDITIONAL SERIAL NUMBERED WEAPON
COMPONENTS WERE LOCATED SINCE 26 JAN 68. TEN. SAC

29 January 1968, doc. 107125

In report #6 from the SAC Disaster Control Team, we learn about the recovery of more weapon parts. A whole paragraph is excised at the beginning of the document. Judging from its sheer size, and of course the fact that it has been deleted, this paragraph may contain a description of important weapon components. Two other descriptions of found parts have been excised as well.

It has only been two days since the Disaster Control Team sent the report contained in doc. 107132. There are many indications that this report is mainly a recapitulation and maybe also a specification of what had been reported earlier. At the same time, it contains information about an apparently significant find made on 28 January. We surmise that the main excised paragraph at the beginning deals with this new find, and again with the four parapacks, three tritium bottles and parts of three separate weapon secondaries. We have not discovered whether the new find of 28 January is the relatively intact secondary that we learn about in Giller's memorandum of 2 February (doc. 318366), or whether it is the fourth tritium bottle (reservoir), which we know was taken back to the U.S. with the first shipment of recovered weapon parts on February 2.


1. THE FOLLOWING COMPONENTS HAVE BEEN FOUND AND IDENTIFIED

BEST AVAILABLE COPY

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105

OTHER WEAPON DEBRIS FOUND INCLUDES UNNER PLATE

SHROUD LINE CUTTER, WEAPON CASE FRAGMENTS, SECTION OF COUPLING RING, CLOSING PLATE, [redacted] THREE 65 FT PARACHUTES (ONE BADLY BURNED) AMD ONE SIXTEEN AND ONE-HALF FT RIBBON PARACHUTE. THE AREA WITHIN THE ZERO LINE MARKINGS HAVE BEEN RANDOMALLY SEARCHED FOR WEAPON FRAGMENTS AND STORED IN ONE BUILDING AT THE SITE. / DELETED DELETED HAVE BEEN REMOVED TO A HEATED RECOVSRY BUILDING ON BASE. OUR MEN WILL CONSENTRAT OF REMOVING THE REST OF THE COLLECTED WEAPON DEBRIS TO THE RECOVERY BUILDING ON BASE. WORK HAS STARTED AT THE SITE TO COLLECT

Behind the black line after the words 'closing plate,' we probably have something like 'a portion of a weapon case 4 by 6 inches'. The one line that has been excised a little further down in the document is probably about 'weapon parts and debris'. These conjectures are based on document 107132.

30 January 1968, doc. 107120

CSAF informs JCS about further weapons recovery on January 28. The description of one or more weapons parts is excised. This document sends report #6 of the SAC Disaster Control Team one step up the chain of command. As noted earlier, the excision may conceal the find of a relatively intact secondary.

ITEM 9. WEAPONS RECOVERY: ON 28 JAN THE [redacted] FOUND

ITEM 10. A RADIOLOGICAL SURVEY POINT FOR

US DOE ARCHIVES

PARAPHRASE NOT REQUIRED

30 January 1968, doc. 107121

This internal memorandum of the AEC summarises what was known to the AEC as of the afternoon of January 26. The documents from these days are basically a set of nested Chinese boxes with a lot of repetition. In the memorandum we learn more about the two objects found on January 25 and mentioned above under January 26 in doc. 107137. In the clipping below, they are said to have been 'tentatively identified as secondary cases' but 'have not been identified with any specific weapon'. However, nothing is said about any content of the cases. Are they empty shells, or

are there any traces of internal components? Perhaps we should remind ourselves of the dimensions, 25 cm x 61 cm.

by association with any specific weapon or weapons. The pieces tentatively identified as secondary cases were found about 2½ miles south-southwest of the aircraft impact point and about 300 yards apart, but have not been identified with any specific weapon.

One of the parachutes 'was in a hole in the ice which measured approximately 30 inches in diameter and which apparently had been caused by something burning into the ice. The water in the hole had refrozen at a level 12 inches lower than the original ice level. It was not known whether the object causing the hole had gone all the way through the ice and into the water.' See sketch of the Thule debris field showing locations of major weapon components. The sketch shows the locations of the parachutes, close to the burned area and the impact point (Chapter 5).

Furthermore, the memorandum mentions cracks in the ice 100 yards north of the burned area: 'Ice in that area was badly fractured and had been badly churned up.' Some of the cracks were up to four feet wide. It was not known 'whether the ice was fractured by the impact of the aircraft or by the subsequent explosion.' At the time of writing, the parachutes had 'not been identified with any specific weapon or weapons.'

mately 25 yards southwest of the edge of the burned area. One of these parachutes was in a hole in the ice which measured approximately 30 inches in diameter and which apparently had been caused by something burning into the ice. The water in the hole had refrozen at a level 12 inches lower than the original ice level. It is not known whether the object causing the hole had gone all the way through the ice and into the water. The fourth parachute was located approximately 100 yards north of the burned area. Ice in that area was badly fractured and had been badly churned up. Some observed cracks were up to four feet wide in the fractured area. It is not known whether the ice was fractured by the impact of the aircraft or by the subsequent explosion. The parachutes have not been identified by association with any specific weapon or weapons. The pieces

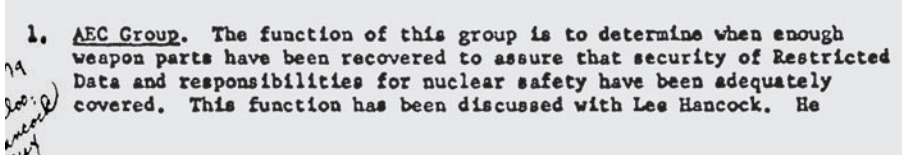
The above description of the state of the ice was confirmed by Dr Børge Fristrup, a Danish glaciologist, who arrived on February 1. Fristrup immediately recognized

that the ice at the north end of the streak had been freshly frozen and that the blocks of ice had been upended and refrozen in abnormal positions. Photographs of the crash site revealed a circular pattern of fracture lines about 600 feet in diameter and a smaller circular area of ice that had been more severely disturbed (see photograph in the appendix of basic crash data. H.D. Bruner's trip report, doc. 107118). Later, Wright H. Langham convincingly argued that the explosions, not the crash, were responsible for the fractured ice (107038). Again, this may be an indication of the destructive consequences of the explosions for the nuclear weapons as well.

30 January 1968, doc. 107123
This internal note within the military division of the AEC describes one of the obvious purposes of operation Crested Ice – to recover enough weapon parts 'to assure [sic] that security of Restricted Data and responsibilities for nuclear safety have been adequately covered.'

Care was taken that the team of Danish scientists did not obtain access to classified information about the weapons. General Hunziker ordered a large room to be set aside for use by the Danish scientists. This kept them out of the classified traffic pattern, although they had full access to general Hunziker and his staff at all times (doc. 107118).

This same consideration is evidently – and not surprisingly – making itself felt today in the sense that it is reflected in the classification policies regulating access to documents on the accident.


1. AEC Group. The function of this group is to determine when enough weapon parts have been recovered to assure that security of Restricted Data and responsibilities for nuclear safety have been adequately covered. This function has been discussed with Lee Hancock. He

31 January 1968, doc. 107119
A cable from CSAF mentions the 'removal of nuclear components to Thule AB for processing.' We can be quite confident that this wording should not be interpreted as plutonium and uranium components, but as weapons components. There can hardly be any doubt that what is being referred to here are the recovered parts mentioned in the earlier documents, for instance, the parts of three secondaries.

CONTINUING FOR 3 OR 4 YEARS. ITEM 9. SEVERE STORMS ALL DAY OF 29TH PREVENTED WORK AT THE SITE. NEXT EFFORTS WILL BE REMOVAL OF NUCLEAR COMPONENTS TO THULE AB FOR PROCESSING AND MADE READY FOR SHIPMENT TO AN AEC FACILITY. ITEM 10. CORE SAMPLING TO

It should be noted that, in a report on his trip to Thule from 23 January to 3 February 1968 (doc. 107118), H.D. Bruner writes that the plutonium of the weapons had been oxidized and aerosolized by the explosion. This reminds us that, as long as we do not have access to more comprehensive lists of the finds, we cannot completely write off the possibility that some tiny fragments of the primary pits might have been found.

Bruner was one of the important figures in the operation. He was assistant director for Medical and Health Research in the Division of Biology and Medicine of the AEC.

1 February 1968, doc. 106969

Again a recovered warhead is mentioned. Strictly speaking, the excision prevents us from knowing whether we have a complete warhead here or only components of one. We cannot even know for sure whether the term as it is used here designates the whole nuclear weapon or only parts of it. There is hardly any doubt, though, that what we have here is the best preserved of the warheads, a relatively intact secondary, also mentioned in Giller's report of 2 February and possibly found on 28 January.

The find of a relatively intact secondary means that this particular weapon was destroyed. Both the primary stage and the tail end of the weapon were missing.

30 FEET X 50 FEET X 5 FEET AND SECURED WITH WIRE NETTING. THE LARGEST PIECE OF AIRCRAFT WRECKAGE WAS A YARD SQUARE SHEET OF HONECOMB. IT WAS CONTAMINATED AND HAD A READING OF 450,000 CPM. ITEM 9. [redacted] WARHEAD WAS PACKAGED ON SITE AND ALL WEAPON ITEMS WERE MOVED TO THE ON-BASE INSPECTION BUILDING.

2 February 1968, doc. 106961
This is the third of the useful status reports from Brigadier General Giller. The idea that something important could be hidden by the above excision would seem to be supported by the fact that this four-page memo for the AEC and its chairman was defined as not declassifiable and removed from the archive folder in 1988. The memo is represented in the 348 batch only by an administrative reference sheet.

The reader should not despair, though: consolation is around the corner. Seven years later, in another declassification round, a copy of the same document was declassified and is represented in our collection as document 318366. We will come back to that soon. Thus, withholding doc. 106961 could perhaps be said to represent a reflection of the less than perfect nature of human bureaucracy rather than of secretiveness. As it turns out in document 318366, the document says nearly nothing that we have not heard before in the other reports from 27 January onwards. Thus, there is hardly any reason why doc. 106961 should be exempt from declassification.

2 February, 1968, doc. 106962
This is the seventh report on the recovery operation from the SAC Disaster Control Team. It does not give us much information apart from some news about the parachutes. However, several paragraphs have been excised, and the document thus serves as a first-rate example of how much classified information some of these reports contain.

The excisions are so comprehensive that it would appear futile to speculate about their content. The best strategy at this point in our investigation seems to be to wait for a later summary of the recovered weapon parts.

As always, when the excisions are comprehensive, our first guess will be that something important has been found.

On a methodological note, and using this document as an example, one could say that it is probably more important to count these 'excised dogs that don't bark' but whose shadows we can see than it is to be too occupied with what is clearly visible, in this case the parachutes.

And then again, the above remark is in fact an exaggeration. We do more or less know what is in the excised paragraphs, or at least we think we know. It can hardly

be anything else than what we already know from 107125, 107128, 107130, 107132 and 318366.

2 February 1968, doc. 106963
This AEC note contains requests and information from Dr Walske as presented in a note of a telephone conversation.

We are told that the Thule team would like to have 'a complete parts list by serial number for each of the four weapons involved in the accident', as well as the isotopic composition of some fissile material.

1. They would like to have available at Thule a complete parts list by serial number for each of the four weapons involved in the accident.

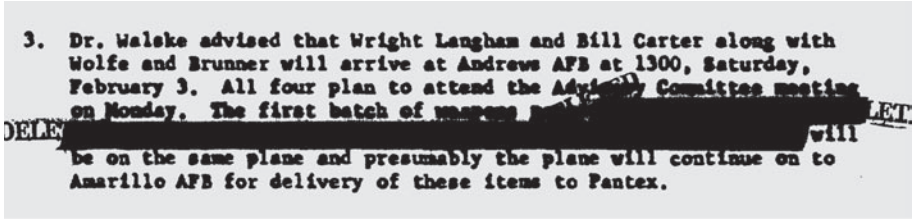
2. They would like to have the isotopic composition of each of the [redacted] pits involved and the age of the material from each of these pits from the last known specific isotopic composition. Also, he would like this information sent to Duane Sewell at Livermore. The information is necessary in order for monitoring people to convert the counts per minute on the gamma meters to micrograms per square meter in order to determine contamination levels.

It is not entirely clear why it was necessary to have a nine-letter word in front of the word pit to characterize it? In order to distinguish it from another kind of pit? In order to emphasize a certain quality about the pit? We do have a long list of nine-letter words, but it is secret.

I have passed on the request to Lee Hancock and he will get the requested information out today with copies to DMA.

CLASSIFICATION CANCELLED

The request was passed to Lee Hancock, the AEC representative in Albuquerque, who was supposed to get the information out the same day, which he did. His answers are probably contained in the withheld doc. 106965, a cable sent some hours later to the AEC representative at Thule at 022107Z February (2 February at 21.07 GMT). Doc. 106965 has been withheld and is represented in the collection only by a reference sheet, but some day it will provide answer to our conjectures.



3. Dr. Walske advised that Wright Langham and Bill Carter along with Wolfe and Brunner will arrive at Andrews AFB at 1300, Saturday, February 3. All four plan to attend the Advisory Committee meeting on Monday. The first batch of weapons [redacted] will be on the same plane and presumably the plane will continue on to Amarillo AFB for delivery of these items to Pantex.

We are informed that 'the first batch of weapons [more than one line deleted]' will arrive at Andrews AFB on February 3. The excision conceals from us any detailed knowledge of the character of this shipment, but we will learn a little more in the next document.

The fact that the shipment took place on a plane which was used by some important American officials was most likely a trivial matter of practical logistics. Furthermore, we learn that this was only the first batch. This could mean that a considerable amount of weapons components had been found already at this stage of the operation.

One of the components in the shipment was certainly the nearly intact secondary. Other items in the cargo were four recovered tritium reservoirs, one of them in a particularly bad shape.

2 February 1968, doc. 318366

This is the document that we think is identical with the non-declassifiable document 106961 of the same date mentioned above. Such inconsistencies in classification and declassification are quite normal for historians working in archives. Somewhat to our surprise, exactly the same has happened with doc. 107004, which was withheld as not declassifiable but is in fact represented in the collection by the very important doc. 317871, which was declassified in April 1995 and thus not available in the 317 collection.

Even more surprising, doc. 104810 of 22 April, about an underwater search for weapons debris at Thule, is still withheld in the collection, though it is in fact represented by the only slightly excised document 107036, which was declassified in May 1988, only a few months after the decision to withhold doc. 104810.

Given the vast number of documents involved in the declassification process, such apparent inconsistencies are bound to appear quite often. Furthermore, inadvertent

releases of restricted data and formerly restricted data are so frequent that DOE sends annual reports to Congress about them. Obviously, what has happened in the first of these cases is that the two identical documents have been handled in different security reviews separated by seven years.

Such things happen all the time and are perfectly understandable: it would be extremely costly to avoid them. But we must admit that it is hard to suppress a smile when we read the U.S. response of September 1995 to nine Danish questions of 22 March 1995. One of the questions was whether the above-mentioned doc. 106961 could be provided to the Danish authorities – if need be, on a privileged basis.

The U.S. response was that the documents that had been completely withheld had been 'retrieved and re-examined in order to verify that the information withheld, either national security information or restricted data, was still classified properly. This was a comprehensive review conducted with an eye towards release. All of the information withheld during the first review was confirmed to still require protection under the Atomic Energy Act or other security guidance. To reveal this information would jeopardize U.S. security interests and violate U.S. policy to prevent the proliferation of nuclear weapons.'

Ironically, an excised version of the requested document was released soon after the 'final response'. It is hard to avoid a sarcastic observation that the situation could not have changed in two months. Perhaps the declassification of 318366 was an act of diplomatic courtesy by an American official. In that case we should not suppress our smile but simply smile – and, before we forget it, kindly ask our American colleagues to put the withheld document 106961 back in the folder. Not that this would provide any new information, but these unnecessarily withheld documents nonetheless foment vague suspicions.

As just mentioned, the U.S. government had stated that the information withheld required protection under the Atomic Energy Act or other security guidance, and that to reveal this information would jeopardize U.S. security interests and violate U.S. policy to prevent the proliferation of nuclear weapons. We readily subscribe to the principle of guarding state and private secrets and, more often than is usually assumed, the guardians of the secrets and the historians can be said to serve the same general public interest, each from their own angle. In general, this is our overall evaluation of the present collection of documents.

That said, this idyllic picture does not hold true in all instances. In this case we have seen quite a number of examples where documents have been withheld erroneously and redactions of documents have been inconsistent. The whole business of secrecy, with its withheld documents, excisions and deleted words, becomes a hornets' nest in which intermingling interests are hard to reconcile.

For the bureaucratic mind the language of the original U.S. decision may seem an effective way of closing a case, but it is also liable to make the hair stand in the case of those readers who are worried about the hidden health hazards or environmental consequences. They will start to think that something very, very suspicious is hidden behind the veil of secrecy.

It is easy to understand how such deficiencies occur, but the tone of imperial infallibility used in defence of a human and error-prone system of secrecy and declassification deserves a little editing as well.

That said, the many cases of inconsistent redaction are to some extent an indicator of considerable openness. When many documents are released, the task of keeping track of different redactions of the same or similar information in copies of the same document spread over different archival holdings and even different countries, as well as of documents that cite each other, sometimes at long intervals and not necessarily with adequate references, can quickly become extremely complicated and hit the security reviewers like a tsunami.

When thinking about lifting a single black line in a document the security reviewer may easily feel overwhelmed by considering the repercussions this might have for scores of other documents. Faced with the workload this might imply as well as the risk of errors, the easy way out for the security reviewer is to uphold the existing classification.

There is generally no reason why historians should feel deceived and adopt an unforgiving attitude towards the archivists, who, with a view to openness, are striving to make information accessible and at the same time guard both private and public secrets. Only when secrecy is used as a veil to hide unwarranted, erroneous or lenient habits of declassification will there be clashes of interest between the historians and the archivists.

Bringing these meandering considerations to a conclusion, we should perhaps remind ourselves that nuclear accidents of this kind are not an everyday event. Contaminating

the territory of other states with plutonium is the exception rather than the rule. Thule and Palomares are two examples of this.

The half-life of plutonium is roughly 24,000 years. In 1995, the U.S. called its answers to the questions of the Danish government a 'final response'. Yet, given the extraordinary character of the event and of the contaminant involved, there can hardly be any final answers or time limits. For good order, it should be noted that the *Final Response to Danish Questions on B-52 Crash* declared that the American authorities 'remained prepared to address additional inquiries should they pertain to new aspects of the 1968 crash' (Final Response 1995).

What the U.S. has done to remedy the situation is good: for example, the removal of contaminated ice, snow and debris. What the U.S. could reasonably do more or do better but has not done is bad. It is not a question that depends on this generation alone or that can be settled once and for all. New knowledge and the evolution of norms can change perceptions, interpretations and priorities.

Some of the secrecy surrounding certain aspects of these events may be the main source of worry and speculation among those who have been most directly affected by the accident, namely the inhabitants of the Thule area. In this light it is disturbing that the security review of the American documents pertaining to the accident was clearly not carried out flawlessly, nor, indeed, given adequate attention by the U.S. Government. It is embarrassing that unnecessarily withheld documents are allowed to feed unfounded suspicions.

A declassification review of the documents pertaining to the accident cannot be performed as a routine matter according to standard procedures such as appears to have been the case in this instance. In essence, it must take the form of a research project within the responsible U.S. agencies with the necessary investment of time and expertise to do the security review and the declassification properly. We cannot tell what that would take, but it should not be a huge project. But until the veil of secrecy can be completely lifted, high priority could be given to declassification reviews at regular intervals with the objective of eliminating all obsolete or unnecessary classification requirements.

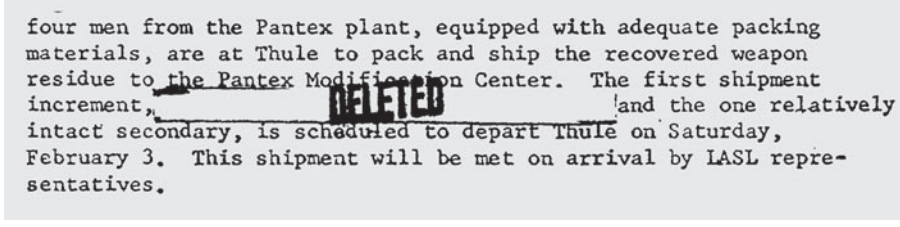
In a recent Presidential Memorandum, President Barack Obama declared that his administration is committed to operating with an unprecedented level of openness concerning classified information and controlled unclassified information

(Obama 2009). Furthermore, with our topic in mind, it is noteworthy that the Secretary of Energy, Steven Chu, reiterated and endorsed the President's Freedom of Information Act policy in a memorandum sent to senior Energy Department officials on 5 June 2009 (Chu 2009).

As far as we know, there is no need for the U.S. side to take into account Danish security regulations or political sensitivities in this matter. On the Danish side, documents from 1968 concerning the Thule accident are available in the archives. This applies, for instance, to the holdings of the Ministry of Foreign Affairs, the Danish Atomic Energy Commission and Risø National Laboratory. In a variety of ways, Danish authorities and research institutions are doing their part, for example, through regular monitoring of the plutonium levels in the area, on land as well as on the sea bottom. International research consortiums have contributed to this effort as well.

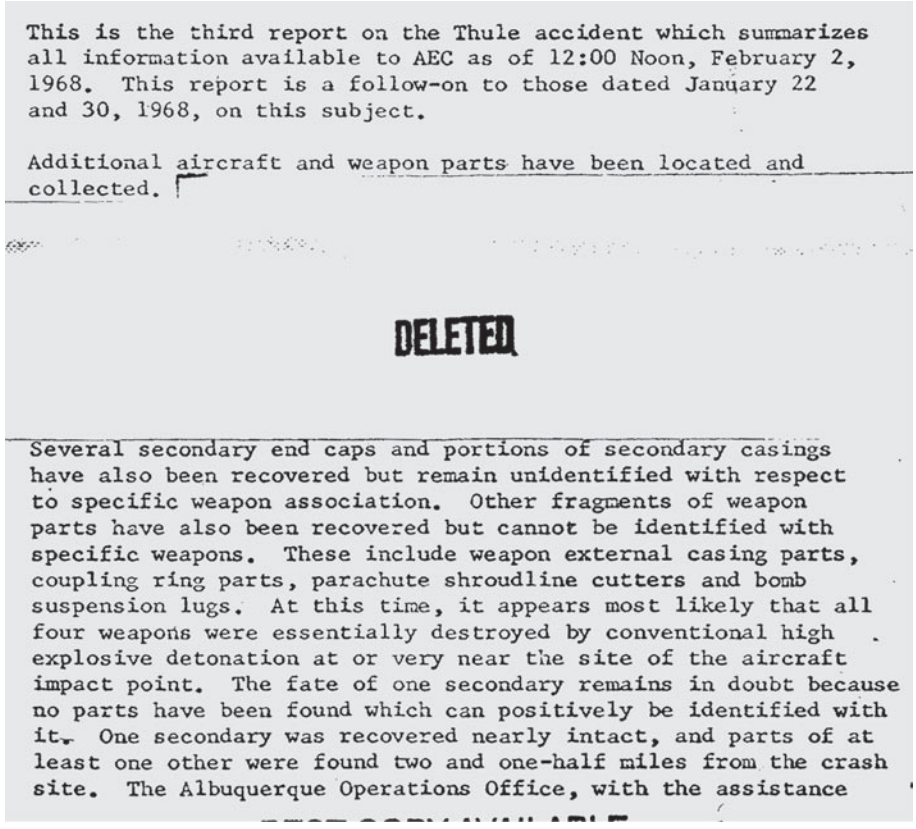
We understand from the literature that general knowledge of the effects and characteristics of plutonium contamination, as well as the concrete analysis and interpretation of monitoring data, will benefit when more precise information on the so-called sources of the fissile material involved in the accident can be released. This could be a favourable outcome, both locally and globally, for the quality of contemporary monitoring and for preparedness in case of future accidents or attacks with so-called dirty bombs (Vantine and Crites 2002).

We now return to doc. 318366. In this third high-level memorandum from General Giller of the Division of Military Applications (DMA) of the AEC to the chairman of the AEC and its commissioners, the shipment in the above document is mentioned once more. One of the items in the shipment, we now learn, was a relatively intact secondary. Details of the other items in the shipment have been deleted in this document in the same way as in the preceding document 106963. The short excision below, after the words 'shipment increment', perhaps simply hides


four men from the Pantex plant, equipped with adequate packing materials, are at Thule to pack and ship the recovered weapon residue to the Pantex Modification Center. The first shipment increment, DELETED and the one relatively intact secondary, is scheduled to depart Thule on Saturday, February 3. This shipment will be met on arrival by LASL representatives.

a few words about parts of two secondaries, but more likely it conceals something a bit more interesting than that.

At the beginning of the memo, there is a summary of the recovered components found from 27 January up to 2 February. As can be seen from the clipping below, a large block has been excised. That paragraph can be assumed to contain important information about the found components, possibly specified to such a degree that it would reveal 'restricted data' about the weapon's design. We cannot be sure about the full contents of the excision, but at least we would expect it to register the finds that were made on 28 January and 1 February.



This is the third report on the Thule accident which summarizes all information available to AEC as of 12:00 Noon, February 2, 1968. This report is a follow-on to those dated January 22 and 30, 1968, on this subject.

Additional aircraft and weapon parts have been located and collected.

DELETED

Several secondary end caps and portions of secondary casings have also been recovered but remain unidentified with respect to specific weapon association. Other fragments of weapon parts have also been recovered but cannot be identified with specific weapons. These include weapon external casing parts, coupling ring parts, parachute shroudline cutters and bomb suspension lugs. At this time, it appears most likely that all four weapons were essentially destroyed by conventional high explosive detonation at or very near the site of the aircraft impact point. The fate of one secondary remains in doubt because no parts have been found which can positively be identified with it. One secondary was recovered nearly intact, and parts of at least one other were found two and one-half miles from the crash site. The Albuquerque Operations Office, with the assistance

According to the report, it appeared most likely that all four weapons were essentially destroyed by conventional high-explosive detonation at or very near the site of the aircraft impact point. However, the fate of one secondary remained in doubt because no parts had been found that could be positively identified with it.

It is equally important to note that the experts at Thule had been unable to match all of the recovered secondary parts with specific weapons. These secondary parts could belong to any of the four weapons and, arguably, most likely to some of those three secondaries that had not been recovered in nearly intact condition.

Incidentally, Gordon Corera is committing an analytical error in basing his conclusions about the final destiny of one of the weapons on such very early and tentative reports. This is why we find it useful to review the documents in chronological order.

4 February 1968, doc. 106960

This report confirms that the aircraft had begun to disintegrate prior to the crash. Pieces of aircraft wreckage, mainly bomb door residue, were found 'almost two miles north of the impact point. These items had zero radiation readings.'

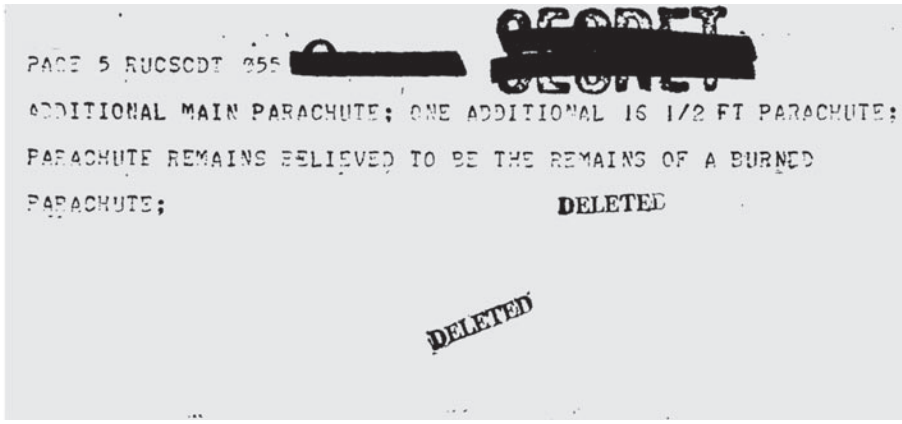
COMPONENTS WERE LOCATED. PIECES OF AIRCRAFT WRECKAGE, MAINLY
BOMB BAY DOOR RESIDUE, WERE ALMOST TWO MILES NORTH OF THE IMPACT
POINT. THESE ITEMS HAD ZERO RADIATION READINGS. RADIOLOGICAL

Weapons components had been 'tentatively identified during pre packing inspections conducted in the on base packing facility.' Whether this refers to the first batch of weapons mentioned above or to newly found components remains somewhat unclear because of the rather comprehensive excision.

PART VIII. WEAPONS COMPONENTS TENTATIVELY IDENTIFIED
DURING PRE PACKING INSPECTIONS CONDUCTED IN THE ON BASE
PACKAGING FACILITY ARE: DELETED

DELETED

DELETED UNIDENTIFIED MAIN PARA-
CHUTE IN CANVAS BAG WITH 15 1/2 FT PARACHUTE UNDERNEATH; ONE


PAGE 5 RUCSCDT 055 [redacted] SECRET

ADDITIONAL MAIN PARACHUTE; ONE ADDITIONAL 18 1/2 FT PARACHUTE;

PARACHUTE REMAINS BELIEVED TO BE THE REMAINS OF A BURNED

PARACHUTE; DELETED

DELETED

The excisions mean that we cannot be sure that all the recovered parachutes are mentioned. The parachutes mentioned in the visible parts of the text maybe only the unidentified ones, since in earlier documents some of the parachutes are associated with specific weapons. One possibility is that all four recovered tritium reservoirs are mentioned in the deleted parts.

Be that as it may, on 19 March, one and a half month later, the parachutes and all four tritium reservoirs had been identified with a weapon. This concludes the microanalysis of the first few days. Future students with more time at their disposal may be able to squeeze more information out of these documents and correct some of the mistakes that we may have made here.

Special aspects of the search operations and Danish-U.S. negotiations

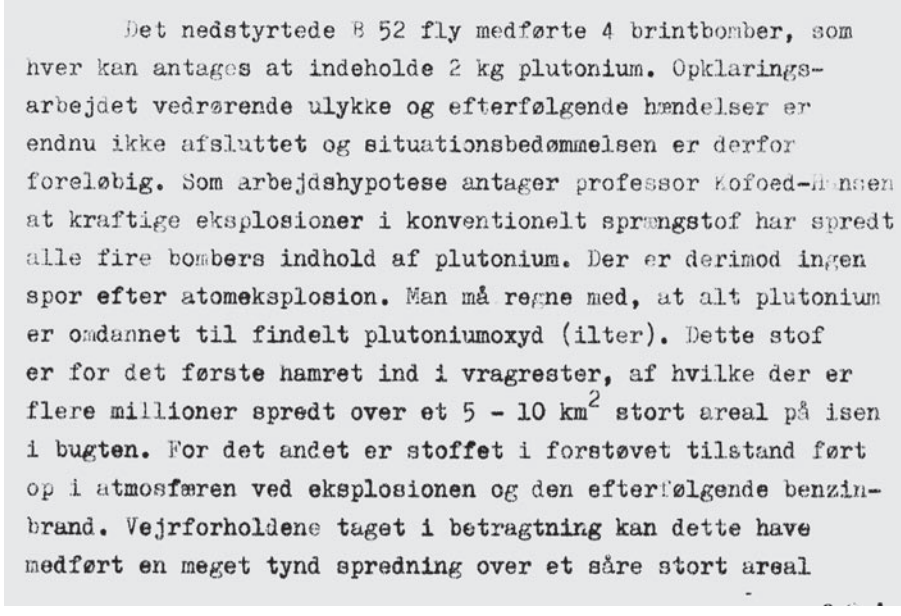
4 February 1968, doc. 106959
Report #10 from CSAF tells us that the State Department representative on the SAC Disaster Control Team believed that Professor Kofoed-Hansen, who by now had left Thule for Copenhagen, was bringing with him a personal report that would contain exaggerated estimates of area affected by plutonium. This appraisal did not even come close – definitely no cigar.

In reality, what happened when Kofoed-Hansen returned to Copenhagen was that he offered a very low estimate of the plutonium contents of each weapon to the Atomic Energy Commission as compared to what was generally believed at the time. Professor

Koefoed-Hansen's estimate was 2 kg of plutonium for each weapon. As we shall see later, this estimate was a good one. Partly, of course, it was based on the observations of the Danish scientists in Thule, but it is hard to believe that he should not have considered it confirmed in exchanges with American colleagues in Thule (Notits 5/2 1968). Later on, in another document – a report written by the American group of scientists at Thule – we learn that 2 kg was what the Danish scientists generally believed, and that the American scientists agreed to discuss the accident with them on that basis (Crested Ice SAC 1969, Vol. IV, Annex i).

5 February 1968, H.H. Koch notat

In a preliminary memorandum, H.H. Koch, Chairman of the Danish Atomic Energy Commission, wrote that Kofoed-Hansen had returned from Thule via the United States. On the plane from Thule with the relatively intact secondary in the cargo, he may have used the opportunity to continue discussions with his American colleagues, Dr Bruner and Dr Langham. Kofoed-Hansen had informed representatives of the Commission, the Ministry for Greenland and the Ministry of Foreign Affairs that each of the four bombs was thought to contain 2 kg of plutonium.



Det nedstyrtede B 52 fly medførte 4 brintbomber, som hver kan antages at indeholde 2 kg plutonium. Opklarings-arbejdet vedrørende ulykke og efterfølgende hændelser er endnu ikke afsluttet og situationsbedømmelsen er derfor foreløbig. Som arbejdshypotese antager professor Kofoed-Hansen at kraftige eksplosioner i konventionelt sprængstof har spredt alle fire bombers indhold af plutonium. Der er derimod ingen spor efter atomeksplosion. Man må regne med, at alt plutonium er omdannet til findelt plutoniumoxyd (ilter). Dette stof er for det første hamret ind i vragrester, af hvilke der er flere millioner spredt over et 5 - 10 km^2 stort areal på isen i bugten. For det andet er stoffet i forstøvet tilstand ført op i atmosfæren ved eksplosionen og den efterfølgende benzin-brand. Vejrforholdene taget i betragtning kan dette have medført en meget tynd spredning over et såre stort areal

The Professor had given his view of the pattern of dispersal of the plutonium oxide and had recommended that the Danish authorities should ask their U.S. counterparts to remove a reasonable amount of contaminated ice and all the wreckage that could

be found. He felt it unlikely that more than half of the total plutonium burden could be recovered and thought that 35% might be a more realistic proportion (cf. Notits 5/2 1968 by the Ministry of Foreign Affairs).

(100 x 300 km^2). For det tredie er dele af stoffet hamret ind i isen og sneen på isen, ligesom vragrester er sunket ned eller slået ind i isen, blandt andet hvor dennes overflade smeltede på grund af varmen fra benzinbranden. For det fjerde og sidste er isen brudt over et areal med 70 - 1[illegible]0 m diameter næsten cirkulært, direkte under det formodede eksplosionssted. Vragrester og forstøvet plutonium må her været gået igennem isen og må nu formodes at befinde sig i vandet eller på bunden i nærheden. Strømningsforholdene taget i betragtning er der endnu næppe tale om, at disse vragrester er ført langt omkring. Vanddybden under eksplosionsstedet er ca. 200 m.

5 February 1968, doc. 107152 (hand-written), with 106915, 107151 and 107160

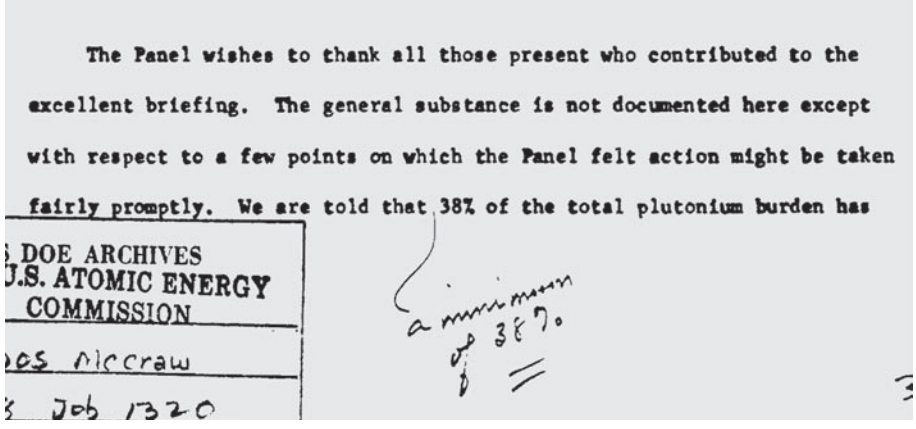
On the same day that Dr Kofoed-Hansen was briefing the Danish authorities in Copenhagen, Dr Langham and others were giving a similar presentation in Washington at a DOD-AEC briefing. The documents listed in the heading are the Chairman's account of the preliminary views of the Safety Evaluation Panel for the Thule incident following the DOD-AEC briefing on 5 February 1968.

Documents 106915, 107151 and 107160 are type-written and identical except for a few things, one of them being a hand-written note on doc. 107151 shown in the first clipping below. The type-written accounts are orderly and easy to understand, but we should notice the sentence in the second line: 'The general substance is not documented here except with respect to a few points…'. It follows that we have to look elsewhere for the substance of the briefing. Where do we find that?

Before we answer this question, we should take note of another revealing difference between the type-written versions. The Chairman's account had already been distributed among the participants of the meeting when the Director of Classification of the AEC, Murray M. Nash, discovered that it should be recalled since it contained 'secret restricted data'. Accordingly, along with a letter of 13 February, the security

officer of Woods Hole Oceanographic Institution returned their 'one and only copy' of the Chairman's account, having already classified it. The doc. 106915 version of the Chairman's account is the one returned to AEC by Woods Hole.

Let us consider the information which had caused the withdrawal of the Chairman's account from Woods Hole: 'We are told that [hand-written: a minimum of 38%] 38% of the total plutonium burden has been located on the snow and ice around the site of the crash; 36% of the burden is within the isopleths corresponding to 100,000 counts per minute as measured on the available instrumentation.'


The Panel wishes to thank all those present who contributed to the excellent briefing. The general substance is not documented here except with respect to a few points on which the Panel felt action might be taken fairly promptly. We are told that 38% of the total plutonium burden has

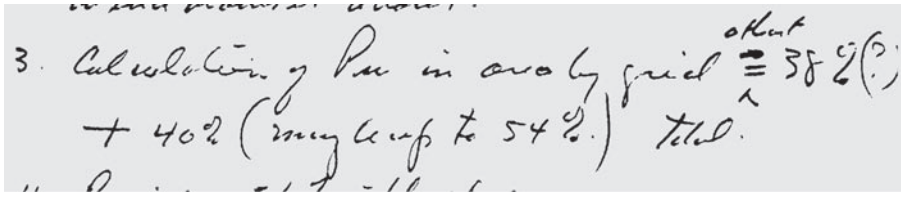
DOE ARCHIVES
U.S. ATOMIC ENERGY
COMMISSION

a minimum of 38%

At the belated intervention of the Director of Classification, this information was classified since it permitted a direct estimate to be made of the amount of plutonium in the weapons. Accordingly, the whole quotation above was deleted in the 1988 security review of the document. The U.S. Government's 1995 'Final Response to Denmark's nine questions' said that a comprehensive review had been conducted to verify that the information withheld was still classified properly. 'All of the information withheld during the first review was confirmed to still require protection.' This statement covers the excision discussed here. As for the claims of comprehensiveness of this second security review, one can add that the information withheld in doc. 106915 can be read in full in docs. 107151 and 107160.

The clipping below is one of the sparkling jewels in the 317 and 348 document collections. The reader should take a deep breath. What we have in front of us is a small piece of the hand-written notes from the meeting. The two lines presented in

the clipping are part of Dr Langham's presentation. These hand-written minutes are, of course, a more valuable source for what Dr Langham said than the deleted version 106915 and the two other type-written accounts in 107151 and 107160, which, as clearly stated, do not cover the general substance.



In his presentation, Langham explained how much of the total plutonium burden had been located on the snow and ice around the crash site. The two lines read: '3. Calculation of Pu [plutonium] in area by grid = at least 38% (?) + 40% (may be up to 54%) total'.

What is unique about the hand-written version is that it has three figures: 38%, +40%, and in parentheses 'maybe up to 54%', whereas two of the typewritten versions have only one figure, 38% cf. doc. 107151, above, with its hand-written addendum under '38%' saying 'a minimum of 38%', and even this one figure is deleted in doc. 106915, thus telling us exactly which piece of information caused the Director of Classification so much anxiety. Only the hand-written version gives us the complete key to a question that has been discussed ever since the accident took place.

Among the radiological survey data at Dr Langham's disposal for his briefing was a thirteen-page report of the initial radiological survey, performed along 30 degree radials and ready on 1 February 1968 (Walske-Koch 15/4 1968, enclosure 1; Crested Ice SAC 1969, Annex B, Appendix III). Also available at this time was the first isodose chart (doc. 107148, figure V). The validity of the 1 February radiological survey was later confirmed in the twentieth situation report from the SAC Disaster Control Team of 17 February (doc. 106904), in which the results of a close grid (50 foot interval) radiological survey of the burn area, completed on 14 February (doc. 106906), were discussed. As far as a historian can judge, the early survey data do not differ in any substantial way from later ones. We find it fairly safe to proceed on that assumption.

The figures presented in the hand-written version are expressions of the minimum, median and maximum estimates in percentages made for plutonium dispersed on the snowpack and the ice. For our purpose, it is of no importance whether these estimates

were precise or not, as long as we know what Langham's kilogram estimates were at that particular date. The amounts expressed as percentages of the total plutonium burden correspond to the minimum, median and maximum estimates of dispersed plutonium in the snowpack and the ice expressed in kilograms. We have used the usual figures for plutonium on snow and ice: 2.8 kg as the minimum and about 4 kg as the maximum. It is obvious that our argument is dependent on the assumption that these were the figures Langham used. We have checked whether there is roughly the same relationship between the two sets of figures 38:54 and 2.8:4, and there is.

The total plutonium burden is equal to the content of plutonium in the weapons. Langham had as his fixed value the amount of plutonium in the weapons. He also knew the minimum, median and maximum estimates for plutonium in snow and ice in kilograms. It follows that it was easy for him to tell the panel the minimum, median and maximum percentages of the 'total plutonium burden' in the ice and snow.

Now that we have been told these percentages and are fairly sure that we know Langham's other data as well, it is equally easy for us to calculate the total amount of plutonium originally contained in the weapons before dispersal, which for so many years has been the 'great unknown', the 'Mother of All Secrets', the 'Holy Grail'. The result is about 7.5 kg.

Wright H. Langham's figures for the plutonium burden from the four Thule bombs (doc. 107152)

	Minimum	*Median*	*Maximum*
Langham's estimate for plutonium on snow and ice in pct [author's note: the median pct would be 45 pct]	38 pct	+ 40 pct	54 pct
Our assumption of Langham's underlying estimate for plutonium on snow and ice in kg	2.5 kg 0.3 kg 2.8 kg	3.1 kg 0.3 kg 3.4 kg	3.70 kg 0.35 kg 4.05 kg
Our calculation of total plutonium burden / contents of four weapons based on Langham's figures	100 pct = 7.4 kg		100 pct = 7.5 kg

For four decades, clearly signalling that they were not compromising secret data, the Americans have called the figure of 6 kg an approximate value and a very reasonable estimate, and they have been right. Now, have we really discovered the Mother of All Secrets? No, of course not. This big secret is simply a sedimentation of past necessities, a dogma, once meaningful, that has gradually become an empty ritual. However, as with all dogma, it is hard to give it up.

By the same token, we have shown once again that the suspicious State Department official was absolutely wrong in his 4 February report. We have seen that Professor Kofoed-Hansen's and Dr Langham's assessments of the plutonium contained in the weapons and dispersed in the explosions corresponded very well with each other.

We are, of course, not leaving the jewel in the crown at that, but will take another look at it in Chapter 5. Suffice it to repeat here that this document was released in 1994 as part of the 317 collection, that is, before the solemn language of the 'Final Response to Danish Questions', where the qualities and necessities of the security review system were pompously impressed on the slow Danes. It has, in other words, been accessible for fifteen years.

8 February 1968, doc. 106940
Telex about the handling of four (tritium) bomb reservoirs from Lee Hancock, AEC representative, Albuquerque, to G. Stone, DMA, AEC, Washington.

The following quotation in the document comes from a Los Alamos message of 7 February 1968, which says: 'Reservoir nos. 1A1-14582-22, 1A1-63685-42, 1A1-63875-42 and 1A1-53057-22 were removed from container nos. JP 65711C9, JP 65273C9 and JP 65547C9 during the period February 5-6, 1968.'

According to Lee Hancock's report of 20 February (doc. 106883), the four (tritium) bomb reservoirs had been sent to Los Alamos with the first shipment of weapon debris from Thule on 2 February. Like, for instance, a nearly intact secondary, they too had accompanied Kofoed-Hansen, Langham and other scientists on the flight back to the U.S. We thus know that all four tritium reservoirs had been recovered before 2 February and sent to Los Alamos for further identification and measurements.

We will comment on the importance of the recovery and identification of all four reservoirs later.

14-16 February 1968, docs. 106899, 106907, 106908
Two days of meetings took place in Copenhagen between Danish and U.S. officials and scientists. The extent of the plutonium contamination was discussed and an agreement reached on the modalities of the continued monitoring of the situation, as well as the removal of the contamination on snow and ice. In his summary of the negotiations, Carl Walske called it a 'gentlemen's agreement'.

The high-level composition of the negotiating teams and the thoroughness of the discussions show the considerable care that was devoted to remedying the consequences of the disaster and the excellent spirit of cooperation between the two teams, which prevailed in spite of negotiating positions that, at least from the outset, were quite far apart. The negotiations and communications between the two sides are testimony to a very professional handling of a crisis.

24 February 1968, doc. 106887
SAC Disaster Control Team report #27.

In this document, we follow some of the efforts to locate the remains of fissile and fissionable materials in the weapons. The same can be seen in doc. 106893 of 22 February. On 6 February, a special effort had been initiated to search for uranium 235. This special part of the weapon recovery operation went on for over a month in this format, but continued all along with other methods until the conclusion of the diving operation in August.

This proved useful in detecting weapon components buried in snow and ice. Daily search activities with PRM5/SPA-3 equipment were continued until weapons search efforts were reduced in March (Crested Ice SAC 1969, Annex B). This effort is also mentioned in a telex of 6 February from the SAC Disaster Control Team in Thule, which mentions experiments with the same equipment to locate large sources of uranium 235 (set at 185 keV) and plutonium (set at 375 keV) (doc. 106954). We have seen no indication that a search for large sources of plutonium should have yielded any results. With the amount of information at our disposal, the plutonium part of the operation would seem rather hypothetical.

These daily activities can be followed to some extent in the documents (Crested Ice SAC 1969, Annex B, Appendix I). As mentioned, the measuring instruments used for this purpose were the SPA-3 probes, which were set at 185 keV, showing that the teams were searching for the actual uranium 235 of the fissile core, the spark plug, of

the secondaries. We are told that 'A 20 pound section [half a line deleted] was found 8/10 of a mile south of the burn area.' That this was not just any piece is shown by the fact that it was 'brought on base to thaw for further identification, packaging and shipment' to Los Alamos.

Shipping this part to Los Alamos was special treatment, since, in his fourth report of 23 February (doc. 106891), Giller had stated that all recovered weapons parts were sent to Rocky Flats except for the tritium reservoirs that had been sent to Los Alamos. This is different from 30 January, when Pantex seemed to be the preferred destination for weapons debris (doc. 107123). The roles of Pantex and Rocky Flats in the handling of weapons parts are mentioned again in a report of 20 February (doc. 106883).

This 20-pound section (9 kg) fits with one of the secondary parts on a sketch of the Thule debris field showing the locations of major weapon components (Chapter 5). We think this 9 kg section contained the fissile core in the secondary of bomb no. 1, SN 690020, a pipe of uranium 235 also known as oralloy. A document from the Directorate of Nuclear Safety says of bomb no. 1 that 'parts of the secondary were found 1 mile and 2 miles south of the southern tip of the burn area' (Broken Arrow Thule 1968). This is fine match for the location of the 9 kg section. The match depends not only on the location itself, but also on the similar language used in the two sources in designating the location.

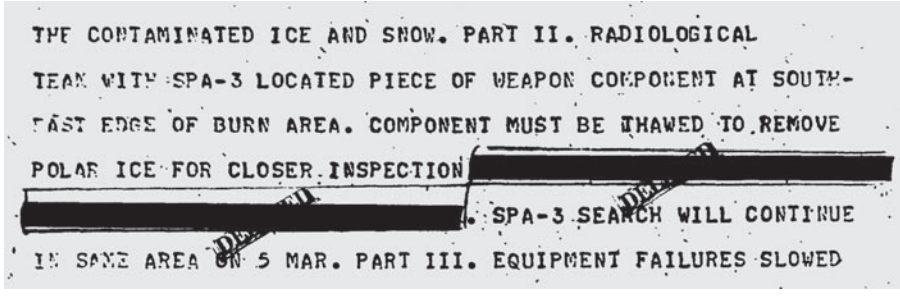
ONE-HALF MILE WIDE WORKING TOWARDS THE BURN AREA. A 20 POUND SECTION
DELETED WAS FOUND 8/10 OF A MILE SOUTH
OF THE BURN AREA. THIS PIECE HAS BEEN BROUGHT ON BASE TO THAW FOR
FURTHER IDENTIFICATION, PACKAGING AND SHIPMENT TO LASL. PART III.
RADIOLOGICAL TEAMS SEARCHED A ONE-HALF MILE SQUARE AREA SOUTHWEST
OF THE BURN AREA USING THE SPA-3 PROBES. NO READINGS ABOVE BACKGROUND

The reader should be reminded that the historian's work in making a jigsaw depends on piecing together a few bits of information from hundreds of blurred, sanitized sources, and that obviously something can go wrong in the process of identifying, choosing and interpreting these small bits of information. However, if we are correct, the reward makes it worth taking the risk. If we are wrong, the security reviewers will have a good laugh.

Supposing that the found section contained a whole fissile core of a secondary, we have learned a few important things: first, that 25 percent of fissile material was recovered from the secondaries in this find; secondly, that the fissile core of the secondaries may have weighed about 8-9 kg; thirdly, that these items were considered sufficiently important to make a targeted effort to recover precisely these fissile cores and finally, confirmation that they consisted of uranium 235. Furthermore, we may have acquired a tool for interpreting other documents in the collection. Of course, we cannot know whether some outer casing was included in the 20 pounds.

5 March 1968, doc. 107007
SAC Disaster Control Team report #42.

The excised part of the document shown below is probably taking note of the recovery of a pit part which we believe to be a piece of uranium 235/oralloy from a secondary pit, occasionally, we believe, called an 'oralloy pit' in order to distinguish it from the primary pit. This observation is based on a comparison with documents 107041 (12 April) and 107047 (1 April). The fact that SPA-3 probes are mentioned both before and after the excised part tells us that we are in the middle of a hunt for oralloy. More will follow about the pit parts. We have not been able to verify this terminology in reference works or consultations with experts. If it turns out to be correct, the lexicographers will have some corrections to make.


THE CONTAMINATED ICE AND SNOW. PART II. RADIOLOGICAL
TEAM WITH SPA-3 LOCATED PIECE OF WEAPON COMPONENT AT SOUTH-
EAST EDGE OF BURN AREA. COMPONENT MUST BE THAWED TO REMOVE
POLAR ICE FOR CLOSER INSPECTION
. SPA-3 SEARCH WILL CONTINUE
IN SAME AREA ON 5 MAR. PART III. EQUIPMENT FAILURES SLOWED

If the oralloy components in docs. 106887 and 107007 were both intact, at least two of the oralloy pits of the secondaries would now have been found.

7 March 1968, doc. 317871
The document is an information meeting item for the AEC on the Thule recovery operations. It has two attachments: a memorandum from the Director of Classification,

C.L. Marshall, dated March 6; and an enclosure to the memorandum, Classification Bulletin WNP-16, dated February 16.

As yet, an example of what appears to be an inconsistent security review doc. 317871 is identical with the withheld document 107004. The excised document 317871 was declassified on 26 April 1995, whereas document 107004 was security-reviewed and withheld on 18 March 1988.

These documents, although still with large excised parts, serve as a perfect illustration of the dilemmas faced by the U.S. authorities in handling the classification issues raised by the accident.

Current classification rules provide that the amount of plutonium contained in a specific weapon is Secret Restricted Data. This information would not be revealed by revealing total quantity of plutonium involved in the accident, provided we can successfully conceal

As the document says, 'current classification rules' provided that the amount of plutonium in specific weapons was 'Secret Restricted Data'. How many kilograms of plutonium were there in the primary pits? That was the question, and the secret.

This piece of secret information, together with a small number of other design details, was in essence what explained the need to have closed classified information circuits during and after the Thule recovery operation.

As we have said before, there is nothing surprising or unusual in this fact. Seen from the perspective of the Director of Classification, it is easy to imagine his reactions when the scrupulously built classification system for which he was responsible suffered the onslaught of such an accident, with all the associated pressures arising from considerations of foreign relations and public diplomacy.

This document might deserve a more detailed examination, but let us confine ourselves to the crux of the matter, which was how much the Danes could be told about the details of the released plutonium without giving them the key to the precise 'Secret Restricted Data'. The logical candidate for the words behind the black bar, the fact that should be 'effectively concealed', is the amount of plutonium found on weapons parts and aircraft debris.

14 March 1968, doc. 909684
Memorandum by W.B. McCool, Secretary of the AEC.

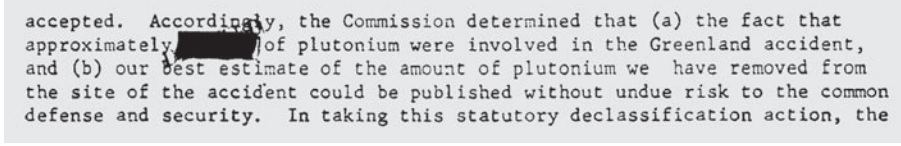
The memorandum summarises the decisions taken at information meeting 780 of the AEC on 11 March 1968. Having considered various alternatives, the Commission had found a compromise. The method of transmitting the desired information through the agreement with NATO had been found not feasible.

Instead, the AEC made a statutory decision that '(a) the fact that approximately [deleted] 6 kg of plutonium were involved in the Greenland accident, and (b) our best estimate of the amount of plutonium we have removed from the site of the accident could be published without undue risk to the common defence and security.'

In taking this statutory declassification action, the Commission concluded that the data should be provided to representatives of the Danish government as 'privileged information' with a request that its dissemination be carefully controlled, and that administrative measures should be taken to appropriately control its dissemination within the United States.

This was probably seen by the Danish authorities as a satisfactory compromise which, on the one hand, gave them the tools they needed to monitor the ecological situation and the health hazards in the area, while on the other hand taking care of one of their other aims, which was to avoid unduly alarming the population. This is an important and legitimate aspect of any responsible crisis management.

It was a small political victory for Carl Walske to have this piece of information declassified. He understood, of course, that it would be impossible to have the exact figure for the plutonium content in the weapons declassified, and settled for a rounded-off value instead. This was, incidentally, sufficient for his purpose, which was to give the Danish government a kind of guarantee that there was no more plutonium in the bombs than it suspected. Carl Walske's handling of this matter shows him to be a diligent operator as well as a broadminded statesman.


accepted. Accordingly, the Commission determined that (a) the fact that approximately [redacted] of plutonium were involved in the Greenland accident, and (b) our best estimate of the amount of plutonium we have removed from the site of the accident could be published without undue risk to the common defense and security. In taking this statutory declassification action, the

Here again we have a couple of exotic flowers in the jungle of the security reviewers. We have to turn to a later document in the collection, doc. 138077 of 18 June 1968, in order to learn that the deleted words in doc. 909684 are '6 kgs.', although this information is present on the website of the Department of Energy and is part of the 'Final response' of 1995.

Incidentally, the short informal notes from the Danish-U.S. meeting in Washington from 18-19 March 1968 are also very discreet in this regard and do not mention whether the newly declassified information about 'approximately 6 kg involved in the accident' was actually disclosed to the Danes on this occasion (AEK 18-19/3 1968).

As noted already, the Marshall memorandum of March 8 (AEC 907/28), on which the AEC was acting at the meeting on March 11, was withheld as 107004 but declassified as 909684.

However, one must take into consideration that there is no absolute coincidence between the real world and the world of bureaucratic decision-making when it comes to putting things on paper for the record.

In the real world, Danish and American scientists were working and relaxing together under extreme and unusual circumstances, and in some cases they were travelling on the same airplanes, with plenty of time for Socratic dialogues about plutonium.

In the real world, the Danish scientists were remarkably well informed about the Holy Grail, that is, the amount of plutonium in each primary pit. In February, Kofoed-Hansen reported to the Danish Atomic Energy Commission that each weapon was believed to contain 2 kg of plutonium (Notits 5/2 1968).

On March 21, another Danish scientist, Asker Aarkrog, noted in his diary and reported in a telegram his impression from a conversation with health physicist Jim Olsen that the total amount of plutonium in the weapons might be roughly 5-6 kg rather than the 7-8 kg that had been assumed by the Danes (Aarkrogs dagbog).

This was ten days after the decision had been made in Washington that the Danes could be informed on a confidential basis that 6 kg of plutonium were involved in the accident. As we have seen, Dr Walske was the prime mover in supplying the

relevant figures to the Danes, and it can be noted that, according to telegrams, he was in regular contact with Jim Olsen in these days.

A report by the U.S. scientific advisory group at Thule tells us about its deliberations with the Danish scientific group. The report confirms that 'the Danish estimate of total active material originally present was about 2 kilograms per weapon or about 8 kilograms. We used their figure in dealings with them.' The report was classified secret and declassified in 1994. It characterizes the Danish scientists as 'an active and capable group' and 'obviously a highly talented one' (Crested Ice SAC 1969, Vol. IV, Annex i). Technically, the Danish group was well equipped to do the job (AEK 29/1 1968).

In yet another American document, the impression of a team of competent Danish scientists is confirmed. Doc. 318355, a memorandum for Dr Walske dated 7 February 1968 on the problem of radiological contamination in the Thule accident, contained a recommendation that a model should be made of the weapons in the aircraft, the distribution of weapon and aircraft debris, and the particle size and distribution of the plutonium. Walske was informed that Sandia Corporation had made similar models in the past, and the memo continued: 'The Danish team has generated such a model, and the U.S. counterparts should be similarly provided.'

A comparison with what may have been believed in the Swedish Defence Research Agency at the time tells us that these Danish estimates were in no way trivial. The Swedish agency was not very precise in its draft of 14 February 1968, which contained the proposed answer to be given by the Swedish prime minister to a member of parliament concerning the contamination in Thule. However, it is most likely that the Swedish agency did not want to be precise and was successfully striving to put together an answer that could be called a triumph of imprecision.

The Swedes had sent their draft to the Danish Atomic Energy Commission in order to obtain its opinion. The Swedish draft listed uranium 235, uranium 238 and plutonium 239, and continued that it was safe to assume that the total amount of these substances did not exceed a few hundred kilograms ('Den totala mängden av dessa ämnen överstiger med säkerhet ej något hundratal kg.').

In their reply to the Swedish question, H.H. Koch and Jørgen Koch wrote that plutonium was the relevant substance – which the Swedes of course knew – and that the amount of that might be somewhere between 10 and 20 kg. H.H. Koch, who had certainly not forgotten the 8 kg reported by Kofoed-Hansen, was probably

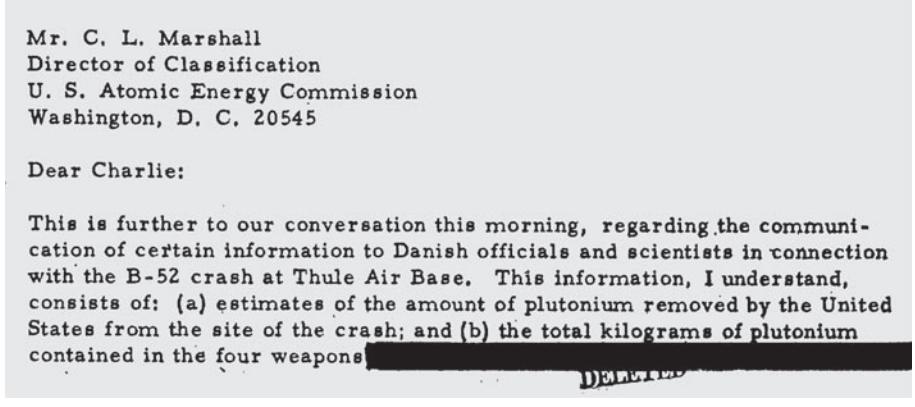
balancing two opposed assessments So as not to let exaggerated ideas of the amount of active material be spread in the Swedish public, and not to compromise the classified data of an ally (Notits 15/3 1968). We have not checked the actual answer of the Swedish prime minister.

We can all imagine how the Danish perception evolved. The Danes obviously obtained their information by a combination of observation and conversation, not by directly communicating precise figures or outright security leaks, but in discussions of the kind where assumptions are aired and counter-assumptions and body language form part of the communication.

Information acquired in this way has two important characteristics: it is useful in assessing situations, but it is also difficult to use in a credible way in any kind of formal public communication because it cannot be corroborated.

14 March 1968, doc. 106996
This document contains an exchange of letters between Dr Walske and the Director of Classification, Marshall. Walske has got his way and can now inform the Danes about the amount of plutonium removed by the United States from the site of the crash and the approximate number of kilograms involved in the accident.

The riddle here consists in the fact that Walske writes 'total kilograms of plutonium contained in the four weapons', after which the next half line is deleted. We can only try to guess what he says here. Maybe something like 'expressed as the approximate amount of 6 kgs. involved in the accident'. Or something about a 'rounded off value ...'.This is a guess. There are several other possibilities.



Mr. C. L. Marshall
Director of Classification
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Charlie:

This is further to our conversation this morning, regarding the communication of certain information to Danish officials and scientists in connection with the B-52 crash at Thule Air Base. This information, I understand, consists of: (a) estimates of the amount of plutonium removed by the United States from the site of the crash; and (b) the total kilograms of plutonium contained in the four weapons [redacted]

DELETED

As noted before, however, we do believe that Walske was basically sincere and well-meaning in speaking in this passage about the total amount of plutonium contained in the weapons, although the words behind the black bar reveal that the figure was going to be an approximation or a rounded-off value, as Walske called it. At the same time we must admit that we have had to travel a long way before being prepared to believe that this figure is roughly correct.

We started out being rather skeptical on this account, thinking that the formula 'involved in the accident' was an ingenuously invented bureaucratic euphemism intended to hide the real contents of the bombs. Gradually we came to the opposite conclusion that it is actually an ingenuous euphemism for disclosing the near truth about the amount of plutonium in the bombs in a format relevant for the Danes at that time, while simultaneously defending the position that the actual plutonium content of the weapons was restricted data.

The question of the plutonium content in the weapons will be taken up again in Chapter 5, where we will summarize the evidence from the available sources.

13 March 1968, doc. 104813
United States Atomic Energy Commission. Memorandum from Edward B. Giller for Chairman Seaborg and others. Fifth status report to the Commission [AEC].

Chronologically, we are close to the Danish-U.S. meeting of experts in Washington, D.C. which took place on 18-19 March 1968.

This is the fifth in a series of status reports to the Commission on the Thule B-52 accident situation. This report briefly summarizes information available as of 5:00 p.m., March 11, 1968.

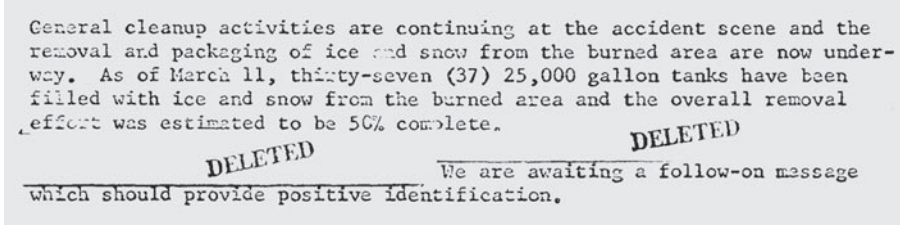
Except for parachute material, all weapon residue received at Rocky Flats and LASL has been examined. DELETED

DELETED

The ten (10) urine samples which were sent to Wright Patterson Air Force

The remarkable thing about the fifth status report is again the excision. The dog neither bites nor barks, but it does grumble a bit.

This memorandum is contained in our batch of documents in another copy as well (doc. 106998). The excisions in the two copies are identical but for one small difference. Here we have the relevant paragraph in *doc. 106998*:


General cleanup activities are continuing at the accident scene and the removal and packaging of ice and snow from the burned area are now underway. As of March 11, thirty-seven (37) 25,000 gallon tanks have been filled with ice and snow from the burned area and the overall removal effort was estimated to be 50% complete.

DELETED DELETED We are awaiting a follow-on message which should provide positive identification.

The difference is that the last one and a half lines have been deleted in doc. 104813. We may ask 'positive identification of what'? Of a relevant weapons part, one would think, that had probably been tentatively identified already. Are we talking about the oralloy part found on 4 March (doc. 107007)?

Another remarkable feature of this document is its discussion of the desirability of and methods for obtaining a material balance for plutonium. Obtaining a material balance was considered highly desirable (a) to satisfy AEC's interest in the amounts that were to be disposed of; (b) to satisfy AEC's interest in the long-term health and safety aspects of the amount of material that was not removed from the incident site; and (c) to reassure the Danish government that an adequate clean up had been completed. Among the desired activities were measurements for three categories in particular: liquid, aircraft debris, and weapons scrap.

The final results of measurement in these three categories have not yet been provided to the Danish government. To say the least, the understanding of the interests of the Danish government in this regard was more pronounced in 1968 than, for instance, in 1988 or 1995. If the U.S. government chose to send this information to the Danish government tomorrow, it would still be a quick response under the perspective of the 24,000 years of plutonium half-life. Quick response is better than *Final Response to Danish Questions on B-52 Crash* (1995). Fortunately, DOE has stated that public input is welcome regarding how the Department may release information of legitimate interest to the public (DOE 1996; cf. Chu 2009).

This topic was also touched upon in the following document.

15 March 1968, doc. 104812
Notes on Thule plutonium, internal memorandum, Division of Operational Safety.

As of 13 March, all significant weapons debris was 'thought to have been collected and sent to Rocky Flats for post-mortem.' It was requested that 'the most accurate estimate possible' should be made of the plutonium quantity in these packages. We do not know the result of the plutonium estimate for the weapons debris. One would suspect it to have been higher than for the aircraft debris, in which, so the memorandum says, 'no appreciable amounts' of plutonium had been found. Maybe Langham did not agree with that. A few days later, he told a Danish delegation that 'perhaps 5% of the plutonium had been impinged into aircraft parts' (AEK 18-19/3 1968). The lack of knowledge concerning the result of the plutonium estimate for the weapons debris negatively influences contemporary attempts to establish a material balance of the plutonium involved in the Thule accident.

Walske's original tactical argument – as we see it – that in order to give the Danes the figure of approximately 6 kg of plutonium it was necessary to conceal the amounts on aircraft and weapons debris hardly applies any more now that we know the figure of 7.5 kg for the contents of the weapons. Under these new circumstances, it would seem a bit dogmatic to uphold any fiction that no measurements were made of these values.

Weapons debris

All significant weapons debris is now thought to have been collected and sent to Rocky Flats for post-mortem. Dow has been requested (TWX from Burke to Woodruff, March 8) to use "whatever technique is feasible" to make "the most accurate estimate possible" of Pu quantity in these packages. There is no reason this material cannot be disposed of via the regular Rocky Flats solid waste disposal system, when no longer needed.

Contaminated aircraft parts

A considerable number of drums, tanks, and spare jet engine containers have been filled with contaminated aircraft debris, checked for external contamination, and stored for removal from Thule by sea. These containers have all been checked externally with instruments which look at the 185-kev gamma from U-235 and at the 60-kev gamma from Am-241 (associated with the Pu). "No appreciable amounts" of Pu were found in these containers (20th situation report from Thule). For gammas in this range, particularly for the 60-kev one, there are great differences in the self-absorption from sources at different positions within containers of metal junk. Therefore, the "no appreciable amounts" finding is pertinent to

19 March 1968, doc. 106985

This is the sixth status report from Giller to the chairman of the AEC. Unfortunately, according to the security reviewer's note, the attachments have been withheld. They would have given us a good picture of the results of the examination of weapons parts at Rocky Flats up to that moment.

The first of the missing attachments is a memo from Hancock to Giller dated 13 March, 1968. The second missing attachment is a report with the title 'Evaluation of Thule weapon debris, with enclosures'.

Unquestionably, it would have been helpful to have access to 'Evaluation of Thule weapon debris, with enclosures', since this is the main evaluation of the first 23 shipments or so of weapons components and debris from Thule.

However, as we shall see in Chapter 5, a short summary report of the recovered weapon parts does indeed exist, although it is excised and is not a complete list. This summary report is not contained in the present batch of documents from the DOE archival facility, but it can be found in the Department of Defense reading room on the internet (Broken Arrow Thule 1968).

We are hinting in particular at the very important information contained in that document that an analysis by the AEC of the recovered secondary components indicated recovery of 85% of the uranium and 94%, by weight, of three secondaries (Broken Arrow Thule 1968). It would not be surprising if this information could also be found in one of the withheld attachments we have just mentioned.

However, what is of the utmost importance in this sixth status report is that it summarises the recovered parts of the fourth weapon, SN 78252. Both the tritium reservoir and the parachutes had been identified as belonging to SN 78252. They were in a worse condition than the similar items from the other bombs. This might very well be an indication that SN 78252 could have been more badly damaged than the other weapons. If that was the case, it would not be surprising that it proved impossible to find other identifiable parts of this bomb. The fourth tritium reservoir had been found at the latest before 2 February, when it was sent to Los Alamos with the first shipment of weapons parts (doc. 106883).

For the official explanation, the reservoir is more important than the parachutes. Already because of the loss of the reservoir, the 'fourth bomb', SN 78252 had become

nonoperational. This is a weighty confirmation of the official version of the fate of the bombs.

Subsequent to the receipt of the above report, we have been informed that inspection of the contents of the weapon parachute packages at Richland Operations has resulted in the identification of the 4' pilot parachute and the 16½' ribbon parachute from weapon SN 78252. The total parts now identified with this weapon are the reservoir, the 64' main parachute, and the above two parachutes.

Additional bits and pieces of weapons are being retrieved during the snow and ice removal operations; however, nothing of significance has been identified. A shipment of weapons debris arrived at Kirtland AFB, New Mexico, on March 17, 1968, and was reshipped to LASL on March 18, 1968.

Identifying these items from the 'fourth bomb', SN 78252, as being in a worse condition than the similar items from the other bombs is an open invitation to hypothesize that, when the Americans were contemplating the possible recovery of a very well-defined missing weapons component, it would perhaps be from one of the other secondaries they had found portions of, rather than from SN 78252, which they may have surmised had been completely split up and, to the extent that it was available at all, perhaps only in tiny unidentifiable pieces, and more likely to have been picked up on the surface of the ice already than to be waiting for the submersible on the sea bottom.

This consideration of probability can perhaps be supported by a rash conjecture which would point at SN 453171 as the more likely candidate for the supply of a missing weapon component.

We base this conjecture on the following passage from doc. 107041 of April 12. A guess would be that the first black spot conceals, for instance, the words 'oralloy' or 'several' or a number, while the second black bar may hide the word 'primary'.

THAN PROCESS VARIATIONS. WE HAVE IDENTIFIED DELETED PIT PIECES
BUT HAVE BEEN UNABLE THROUGH CHEMICAL ANALYSIS TO ASSOCIATE PARTS
SPECIFICALLY WITH BOMBS 453171 OR 78252. NO PIECES HAVE BEEN YET
IDENTIFIED TO BE FROM DELETED PITS. WE WILL ANALYZE PIT PARTS

If our assumptions here are correct, the meaning of the paragraph would then be that some pieces of uranium 235/oralloy from the secondary pits had been identified with bombs SN 690020 and SN 815950, but not with SN 453171 or SN 78252, whereas no pieces had been identified as being from the primary pits.

In trying to interpret this, the first thing we should remember is that uranium 235 was present in the primary pits in higher quantities than plutonium. There is also some likelihood that at least some of the uranium and plutonium in the primary pits would have integrated to some degree either in the production process or in the explosions. If such pieces had been found, it would not have been difficult to distinguish them from pieces of pure uranium 235 coming from the secondary pits, especially since it seems reasonable to assume that the oralloy in the primary pit was of a higher grade than the oralloy in the secondaries.

If this line of reasoning is correct, it would increase the likelihood that no pit pieces from the primaries had been recovered. This would be consistent with the general picture that all the fissile material in the primaries had been dispersed in particulate form in the explosions. This would at the same time decrease the likelihood that there would be any pieces of the primary pits to take into consideration in the final calculation of dispersed plutonium. Not having access to the evaluation reports of the first 23 shipments of recovered weapons parts, this is, of course, only an assumption.

Continuing along this rather speculative path, we would then surmise that all the recovered pieces of uranium 235/oralloy came from the secondaries. From a USAF document that cites an AEC analysis, we know that substantial quantities of uranium were in fact recovered, to be precise 85% of the uranium from three secondaries.

The full quotation goes like this: 'An analysis by the AEC of the recovered secondary components indicates recovery of 85% of the uranium and 94%, by weight, of three secondaries. No parts of the fourth secondary have been identified' (Broken Arrow Thule 1968).

Let us keep this in mind when we come to the analysis of the 'missing component'. We should note, though, that we cannot know whether the 85% is a reference to all kinds of uranium present in the secondaries, including natural uranium (tuballoy), or only to uranium 235.

30 March 1968 marked the official termination of the evaluation and recovery portion of Crested Ice. This date gives a somewhat better understanding of the situation than Lee Hancock's remark in doc. 106883, where he reported that the search for bomb and aircraft debris on the surface of the ice was considered complete as of 20 February. This is not correct, or should at least be understood as meaning that now the hunt had changed format and had become a search for parts buried in the ice. While Hancock was writing his sentence, the hunt for oralloy parts was continuing on the ice.

18-19 March 1968, AEK 18-19/3 1968
Notes [informal] from Danish-U.S. meetings in Washington. This was the meeting where the so-called 'Gentlemen's Agreement', which had been reached in Copenhagen a month earlier, was supplemented and finally codified.

Let us make just a few points from the Danish notes. First, Walske said that all information about absolute amounts was confidential. It is not said in the notes whether the figure of approximately 6 kg was mentioned. Secondly, Langham estimated that 'perhaps 5 percent of the plutonium had been impinged into aircraft debris.' Assuming 7.5 kg of plutonium in the four weapons, this would equal roughly 0.4 kg.

Walske mentioned that 'the U.S. would like to search for attractive parts.' This could, of course, only be understood as weapons parts. H.H. Koch answered that the Danish authorities would scan the area and discuss the results with the American side if something was found. A little later, Koch asked whether there was going to be a sea bottom survey. Walske proposed a formulation, which in the final agreement runs as follows: '11. The question of a possible sea bottom search was reserved for further study of costs and utility by the U.S. Air Force. Should such a search be undertaken, the results would be made available to the Danish AEC.'

Koch agreed to this solution, and Walske explained that the U.S. 'would hardly recover anything. The Air Force would like to know something, but would rather not drag out the operation. There was also a cost consideration.' ['Walske: Vi henter næppe noget op. Airforce vil gerne vide noget, men vil nødigt trække afslutningen ud. Også cost consideration.'].

The above remarks by Walske indicate that, already in the middle of March, it was known that an 'attractive' weapons component was missing. We see here some of the first signs that a bottom survey might become desirable. Contrary to what the

BBC journalist, Gordon Corera, believes, the Danes were told early on that the U.S. might decide that it would be desirable to search for 'attractive parts'.

From a purely chronological point of view, we are in the middle of a chain of events with uranium 235, also known as oralloy, playing an active part. This begins with a specific effort to recover oralloy parts on 6 February. Further on, some of the main events are finds of some of the oralloy parts at the end of February and the beginning of March, the possibility of an underwater survey in the Danish-U.S. agreement of 19 March, then the Sandia report of 2 May 1968 (doc. 107032), in which the missing object is defined. Further events on the timeline are, for example, a meeting in Copenhagen on 18 July 1968 between General Glasser and H.H. Koch with seven participants (see below) concerning a bottom survey, and finally, the dives in Thule in August and the debriefing of participating Air Force officers in September 1968.

19 April 1968, doc. 107038
Memorandum from H.D. Bruner, Assistant Director for Medical and Health Research, Division of Biology and Medicine, AEC. The subject of the memo is the conference with the Danish representatives at the Pentagon, *March 18-19*, which we have just followed in the Danish notes. It is a useful seven-page document with appendices, and well written.

One fascinating aspect of the document seen from a weapons-recovery point of view is Dr Langham's formidable reconstruction of the crash and what happened to the bombs in the second that the nose of the aircraft hit the ice. In an interview many years later, in 1995, Langham's wife, Julie Langham Grilly, still remembered that he was very involved in discovering how the plane had come in (Grilly 1995).

In any discussion about the perhaps special fate of one of the bombs based on the apparent utter destruction of one of the tritium reservoirs and one of the parapacks, the following part of Langham's reconstruction is of special relevance. Here is what Bruner wrote about this part of Langham's presentation: 'The high explosive of the weapons detonated beneath the main fuel tanks and hence the amount of fuel in the center of the cracked area is minimal. The very high explosive force of the weapons would account for the reticular arrangement of fracture lines and distorted iceblocks. He also postulated that one weapon exploded first and its shock wave then set off the other three. It seems likely that the explosion disintegrated the Pu and alloy,

and surrounded as they were by fuel tanks, etc., this metal ought to be impacted on and into the surfaces of one side of many, but not all, pieces of wreckage metal; this is what was found.'

1 April 1968, doc. 107047
Report about examination of shipments of weapons debris nos. 24 and 25 from W. Lee Hancock, representative of the AEC at LASL, Albuquerque, New Mexico, to General Giller in AEC Headquarters, Washington.

This report and the subsequent doc. 107041 of 12 April are interesting in that they give us an idea of what it would have been like to have access to the main report of this kind, that of 13 March covering the examination of the first 23 shipments. There is a link between document 107007 (6 March), the present 107047 (1 April) and the subsequent 107041 (12 April).

The items in these shipments were presumably shipped from Thule after 6 March (doc. 107007).

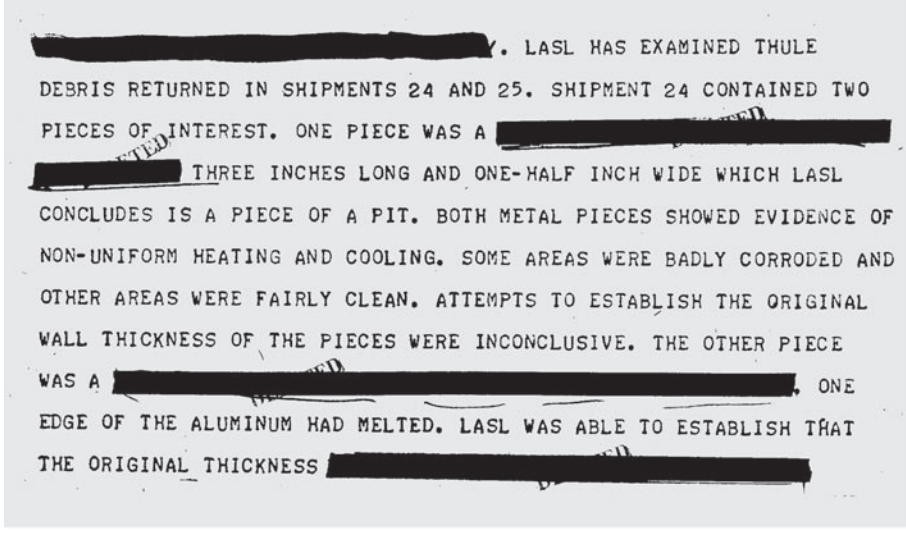
Two pit pieces and one secondary piece have been examined at Los Alamos. The fact that the pieces had been sent to Los Alamos first instead of directly to Rocky Flats might be of significance in itself, perhaps an indication that the pieces were believed to be oralloy.

The first piece, called 'a piece of a pit', was 'three inches long and one half inch wide'. Another object is also identified as a piece of a pit. The pit parts were 'sent to Rocky Flats for further inspection and analysis'.

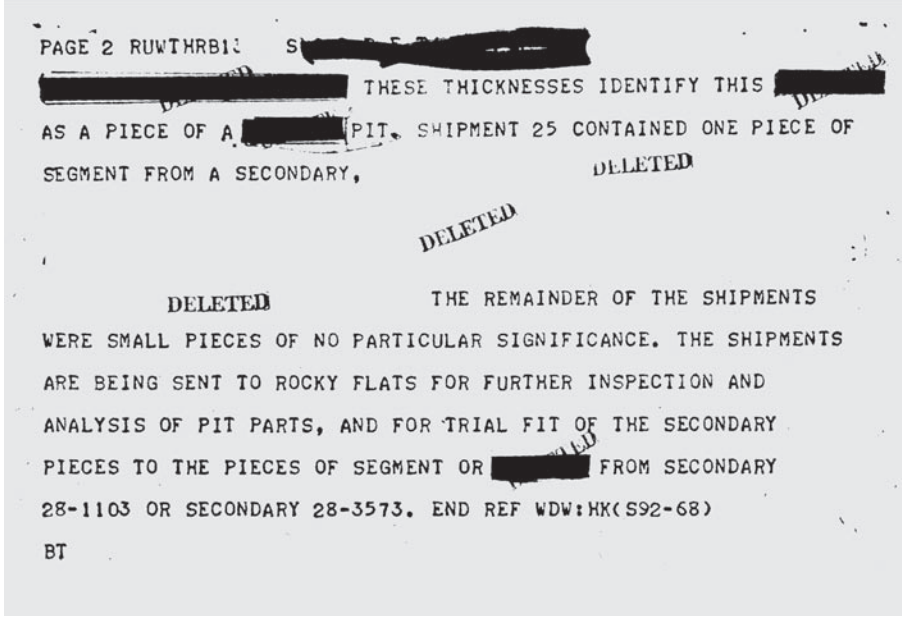
'One piece of segment from a secondary [several lines deleted]' had also been examined. It, too, would be sent to Rocky Flats for 'trial fit of the secondary pieces to the pieces of segment or [word deleted] from secondary 28-1103 or secondary 28-3573.' The secondary numbers are specific for the secondaries and differ from the bomb numbers.

We can speculate that these two secondaries were less than intact, possibly in bits and pieces, as opposed to a third secondary, which had been recovered relatively intact. In doc. 106854 the two secondaries are described in these words: 'other pieces of secondaries now at Rocky Flats'. It could well be that the 'missing weapon component' belonged to one of these two secondaries.

SN 690020 was the relatively intact secondary, whereas SN 453171 and SN 815950 had fared worse. As discussed earlier, we believe that some pieces of uranium 235/oralloy from the secondary pits had already been identified with bombs SN 690020 and SN 815950, but not with SN 453171 or SN 78252. This conclusion is supported as far as SN 690020 is concerned by our analysis of the recovery of the 20-pound



[redacted]. LASL HAS EXAMINED THULE DEBRIS RETURNED IN SHIPMENTS 24 AND 25. SHIPMENT 24 CONTAINED TWO PIECES OF INTEREST. ONE PIECE WAS A [redacted] THREE INCHES LONG AND ONE-HALF INCH WIDE WHICH LASL CONCLUDES IS A PIECE OF A PIT. BOTH METAL PIECES SHOWED EVIDENCE OF NON-UNIFORM HEATING AND COOLING. SOME AREAS WERE BADLY CORRODED AND OTHER AREAS WERE FAIRLY CLEAN. ATTEMPTS TO ESTABLISH THE ORIGINAL WALL THICKNESS OF THE PIECES WERE INCONCLUSIVE. THE OTHER PIECE WAS A [redacted], ONE EDGE OF THE ALUMINUM HAD MELTED. LASL WAS ABLE TO ESTABLISH THAT THE ORIGINAL THICKNESS [redacted]



PAGE 2 RUWTHRB1[redacted] [redacted] THESE THICKNESSES IDENTIFY THIS [redacted] AS A PIECE OF A [redacted] PIT. SHIPMENT 25 CONTAINED ONE PIECE OF SEGMENT FROM A SECONDARY, DELETED

DELETED

DELETED THE REMAINDER OF THE SHIPMENTS WERE SMALL PIECES OF NO PARTICULAR SIGNIFICANCE. THE SHIPMENTS ARE BEING SENT TO ROCKY FLATS FOR FURTHER INSPECTION AND ANALYSIS OF PIT PARTS, AND FOR TRIAL FIT OF THE SECONDARY PIECES TO THE PIECES OF SEGMENT OR [redacted] FROM SECONDARY 28-1103 OR SECONDARY 28-3573. END REF WDW:HK(S92-68)
BT

section in doc. 106887 of 24 February. In that case we concluded that the recovered fissile core belonged to bomb no. 1, SN 690020.

The reasoning is simple enough. In relation to these two weapons, SN 453171 and SN 815950, it may have been possible to see or at least have an idea of what was missing, and then to give Sandia a complete, very exact description of the missing weapons component, as was done four days later, when the AEC/ALO asked Sandia Corporation to assist in defining an underwater search area off the coast of Thule.

But since we believe that some pieces of uranium 235/oralloy from the secondary pits had been identified with bomb SN 815950, this makes SN 453171 the most likely candidate for a missing uranium part among these three weapons.

One candidate for the 'missing weapon component' could thus be hidden in the excised part of the present document 107047. On the basis of that one piece of segment from a secondary that is mentioned at the start of the deleted paragraph and the state it was in, the experts were perhaps able to deduce something about a component that had been inside the segment but was now missing. We are working blindfold here and cannot, of course, be sure that this is the case. But perhaps this is one place where something is mentioned that refers to our idea of the missing component, namely a piece of oralloy/uranium 235 from the fissile material in the secondary stage of the weapon.

We may or may not be dealing with a situation in which all of the oralloy in the secondary is missing. It might be that only a small broken-off piece of oralloy was missing from the jigsaw. See, for example, the words in the last lines of the clip above. Very soon we will see that the Americans were in fact guessing that an intact oralloy component might be missing, but how could they be sure? They could not, of course. After all, some of the recovered oralloy pieces were rather small.

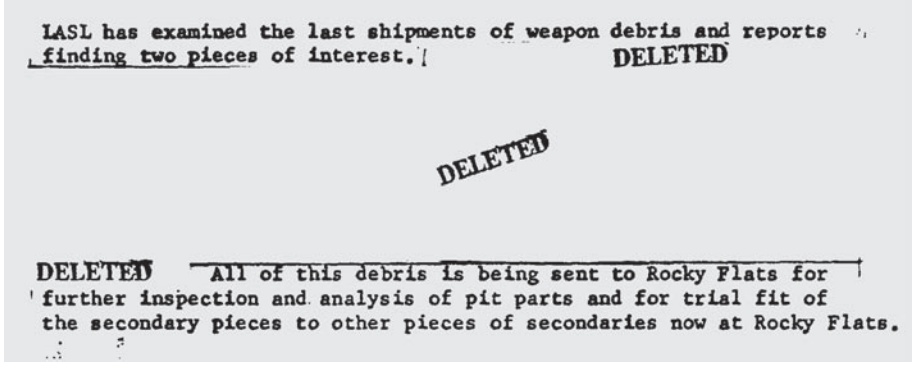
How big would the oralloy (uranium 235) element in the secondary stage be? Maybe about 8 kg, which in volume would be less than 0.5 litres. Uranium and plutonium are both heavy metals, roughly twenty times heavier than water At this stage in our investigation, we cannot be sure of the shape of this component, nor whether it was divided into several sections or whether one of these sections was perhaps of such a sophisticated nature that this feature in itself would make it especially worth looking for.

On the basis of the excised parts of the Sandia document below, doc. 107032, we will speculate a little further on the physical characteristics of the object and whether it was suspected to be whole or in pieces.

Anyway, what is interesting is that what the Americans may have been looking for was something with a volume of less than half a litre. Supposing that this item was at all whole, which they could not be sure of, it could still be said that this would be a very small item to spot on the sea bottom in the middle of thousands of pieces of mainly aircraft debris.

5 April 1968, doc. 106854
Ninth status report from General Giller to the AEC chairman.

This is Giller's summary of Hancock's report of 1 April, which we have just analysed. In his opinion, two of the pieces in Hancock's report are of interest. In spite of the excision in this document, we have the candidates for them in the former document.


LASL has examined the last shipments of weapon debris and reports finding two pieces of interest. DELETED

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DELETED All of this debris is being sent to Rocky Flats for further inspection and analysis of pit parts and for trial fit of the secondary pieces to other pieces of secondaries now at Rocky Flats.

12 April 1968, doc. 107041
Report about examination of shipments of weapons debris nos. 24, 25, and 26 from W. Lee Hancock, representative of the AEC at LASL, Albuquerque, New Mexico, to General Giller in AEC Headquarters, Washington.

This is the last document in the chain of three documents which, so to speak, are our substitutes for the report of 13 March that covers the first 23 shipments, in the sense that, taken together, they are documents of the same type as the report of 13 March.

A. TWO PIECES OF TUBALLOY SEGMENT HAVE BEEN IDENTIFIED BY MATING WITH PREVIOUSLY IDENTIFIED [redacted] SEGMENTS--ONE ASSOCIATED WITH BOMB 453171 AND THE OTHER WITH BOMB 815950.

B. THREE PIECES OF ORALLOY FROM PITS HAVE BEEN ANALYZED FOR

PAGE 2 RUWTHRB15 [redacted]

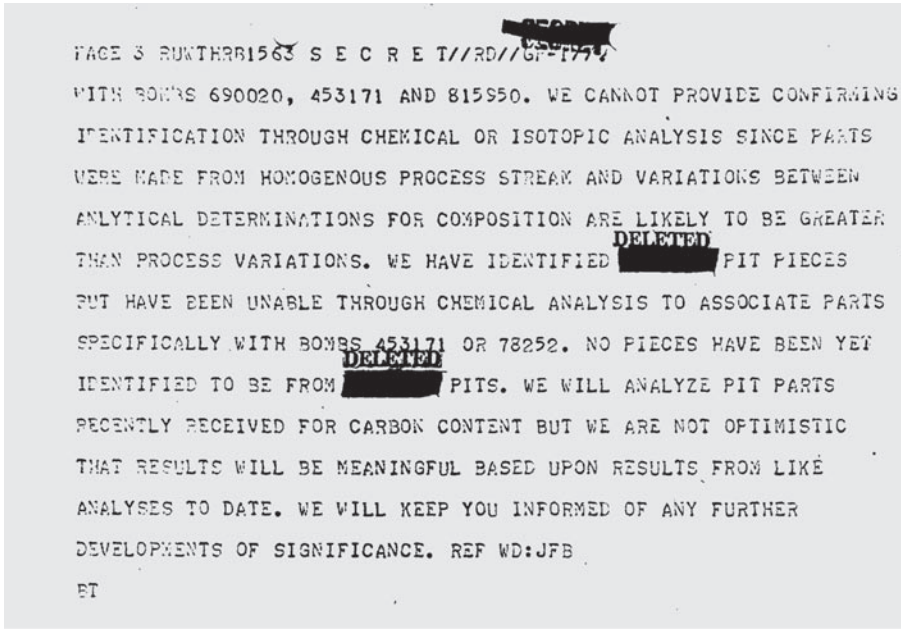
CARBON CONTENT IN HOPE OF ASSOCIATING PIECES WITH SPECIFIC BOMBS. RESULTS OF ANALYSES ARE INCONCLUSIVE. AS PREVIOUSLY REPORTED, TWO PIECES WERE DETERMINED BY THICKNESS MEASUREMENTS TO BE FROM [redacted] PITS AND OTHER PIECE WAS TOO BADLY DAMAGED TO MAKE ACCURATE MEASUREMENT.

C. ANOTHER PACKAGE, NUMBER 26, HAS BEEN RECEIVED AND CONTENTS EXAMINED. PACKAGE INCLUDED:

1. TWO PIECES URANIUM COLLAR - UNIDENTIFIED
2. ONE PIECE OF STEP JOINT OF SEGMENT - UNIDENTIFIED
3. FOUR SMALL PIECES OF TUBALLOY [redacted] - ALL LESS THAN ONE INCH SQUARE AND UNIDENTIFIED
4. ONE PIECE URANIUM FROM PIT - UNIDENTIFIED
5. FIVE SMALL PIECES OF TWO-LAYER PIT LAMINATE - BADLY DAMAGED BUT MEASUREMENTS INDICATE THEY ARE PROBABLY FROM [redacted] PIT.

D. ONE MORE PACKAGE, NUMBER 27, DUE TO ARRIVE AT LASL MOMENTARILY CONTAINING ONE SMALL PIECE OF UNIDENTIFIED MATERIAL.

IN SUMMARY, EVALUATION AND IDENTIFICATION EFFORTS WHICH HAVE TRANSPIRED SINCE OUR CONCLUSIONS WERE TRANSMITTED TO YOU ON DOE ARC MARCH 13 HAVE NOT REVEALED ANYTHING WHICH ALTERS OUR PREVIOUSLY EXPRESSED OPINION. ESSENTIALLY ALL TUBALLOY SECONDARY PIECES HAVE BEEN IDENTIFIED BY SERIAL NUMBER OR FIT TO BE ASSOCIATED



PAGE 3 RUNTHRB1563 S E C R E T//RD//GP-1//

WITH BOMBS 690020, 453171 AND 815950. WE CANNOT PROVIDE CONFIRMING IDENTIFICATION THROUGH CHEMICAL OR ISOTOPIC ANALYSIS SINCE PARTS WERE MADE FROM HOMOGENOUS PROCESS STREAM AND VARIATIONS BETWEEN ANLYTICAL DETERMINATIONS FOR COMPOSITION ARE LIKELY TO BE GREATER THAN PROCESS VARIATIONS. WE HAVE IDENTIFIED [redacted] PIT PIECES BUT HAVE BEEN UNABLE THROUGH CHEMICAL ANALYSIS TO ASSOCIATE PARTS SPECIFICALLY WITH BOMBS 453171 OR 78252. NO PIECES HAVE BEEN YET IDENTIFIED TO BE FROM [redacted] PITS. WE WILL ANALYZE PIT PARTS RECENTLY RECEIVED FOR CARBON CONTENT BUT WE ARE NOT OPTIMISTIC THAT RESULTS WILL BE MEANINGFUL BASED UPON RESULTS FROM LIKE ANALYSES TO DATE. WE WILL KEEP YOU INFORMED OF ANY FURTHER DEVELOPMENTS OF SIGNIFICANCE. REF WD:JFB

BT

The two short deletions above offer a welcome opportunity to discuss a question of terminology. The problem is simple. These important documents abound with pit pieces and pit parts that clearly refer to the fissile core of the secondaries, but we have not yet found an expert or a piece of literature to confirm that the term 'pit', which is normally reserved for the fissile core of the primary stage, could also be used for the fissile material in the secondaries. The way to distinguish between the two could then, for instance, be to speak of the primary pit versus the oralloy pit.

This usage is probably what we find behind the black bars above. Let us try to put the two passages beside each other and fill the black area in as we believe it should be done:

1) 'We have identified *oralloy* pit pieces...'
2) 'No pieces have yet been identified to be from *primary* pits.'

It follows that the identified oralloy pit pieces do not belong to the primary pits. If we are correct, it was normal usage at this time to speak of a pit not only in the primary but also in the secondaries.

5 April 1968, Walske-Koch 5/4 1968
Letter from Carl Walske to H.H. Koch.

Among other things, Walske answered a question from Koch about the possibility of a sea bottom search. He informed Koch that this matter was being considered by himself and General Glasser, but more in the way of some photography below the impact point rather than a search. The decision would be greatly influenced by whether or not something simple in terms of manpower and expenditure could be devised. Since August would seem to be the most favourable time for such a search, there was still some time before a decision would be necessary. The Navy people were looking into the matter, and Walske expected to be able to give Koch an answer within a few weeks.

Two brief comments may suffice. The first is a rather obvious observation that we are not witnessing the preparations for a high-priority underwater operation. The second is to point out that, with examples of this kind, we have slowly started a brief process of disproving the mistaken assertion of Gordon Corera, the BBC journalist, that the Danish authorities were deceived in the matter of underwater operations.

15 April 1968, Walske-Koch 15/4 1968
Another letter from Walske to. Koch, who had invited Walske to visit him in Copenhagen, where they spent May 28 and May 29 together. As it turned out, the occasion was used for a meeting at the Danish Atomic Energy Commission. Again we think that Corera got it all wrong if he believes that Dr Walske was going to spend two spring days in Copenhagen deceiving Mr Koch.

Enclosed are the radiological survey data from the Air Force accident report, five appendices from Annex B and three appendices from Annex I (cf. Crested Ice SAC. 1969). These same appendices were sent to the Danish government once again in 1988. Yet another letter from Walske to Koch about various matters was sent on May 2, this time with a brief remark that the underwater operation had not been decided on as yet.

22 April 1968, doc. 107036
By the end of April, Sandia Corporation had completed its study of the accident in order to develop the parameters of an underwater search for missing weapon debris. Where was it likely to be found?

The Department of Defense (DoD) was interested in the consensus of the Atomic Energy Commission (AEC) regarding the desirability of conducting an underwater

search. The Air Force had considered various approaches in conducting such a search. The object of the search is probably identified in the deleted passage below, before the words 'under-ice concept'.

The under-ice concept discussed in the document would have had the U.S. Navy as the entrepreneur, but it was discarded as not being within the current capability of the Navy and not doable in the time remaining to conduct search operations from the ice surface prior to ice breakup. This appears to indicate that the Navy's Curv system could have been involved, which had also been employed in Palomares. It all fits with the manner in which the Curv system would have been deployed.

Instead, the Air Force funded the Navy to evaluate various concepts of search operations which could be conducted after the ice had melted and when the bay was clear for surface operations. In the meantime, a group of oceanographers had been working at the Thule site in an effort to estimate where residue might drift as a result of currents. This group was scheduled to brief Walske on 24 April 1968.

The purpose of this paper is to provide background for discussion of the desirability of conducting an underwater search for missing weapon debris at Thule.

The DoD is interested in the consensus of the Commission regarding the desirability of an underwater search and its possible extent.

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The Air Force has considered various approaches to conducting a search [redacted] the under-ice concept was discarded as not within the current capability of the Navy to conduct and the time remaining to conduct search operations from the ice surface prior to ice breakup is considered insufficient. The Air Force has now funded

Later in the document, the Sandia study is mentioned again.

Sandia Corporation has completed a study of the accident to develop an estimated "footprint" on underwater trajectories which may be useful in defining the area for search operations. The report of the results

The Air Force did not expect a very complicated search since the 'water is relatively shallow (approximately 600 feet at most) and the bottom of the bay has the characteristics of a small desert. Considering the fact that the point of entry into the water is pinpointed and the terrain to be searched is smooth, use of a towed sonar sled and closed circuit TV appears to be a logical search approach.'

It appears that at this point in the discussion, the Coast Guard stated its willingness to support the logistics effort and that finally a manned submersible such as the Navy's Perry Link deep diver might also be needed.

As noted previously, Sandia Corporation had already completed a study that could be useful in defining the area for search operations.

The DoD had been giving some thoughts to the desirability of an underwater search. On the one hand, a search would lead to questions about what might be missing and, clearly, even a very extensive search might be unsuccessful. On the other hand, even a brief search might find sensitive classified debris which another nation might recover if the Americans did not. DoD found that a reasonable approach might be to let the extent of the underwater search depend on the results of a brief underwater survey. Now, 41 years later, the sentence that 'a search would lead to questions about what might be missing' has proved itself to be a visionary one.

These considerations reflect very clearly that the missing object was not a bomb. Had this been the case, the argument would have been completely different, and there would have been no discussion of pros and cons. The search would have been performed in a massive way, period. It is obvious that the search in Thule was not even remotely considered as important as the underwater operation in Palomares two years earlier.

The approach proposed by the DoD also shows that it was not at all convinced that the missing object was there or that it could be found. Its attitude could best be described as rather relaxed: 'If the object cannot be found with a relatively limited effort, so be it!'

The arguments we have heard above should, we believe, be taken seriously only to a certain extent. They are reminiscent of a not so unusual pattern of behaviour in bureaucratic systems, in which many agencies and individual agents have a tendency to cover their backs against the eventuality that some superior or competitor should

ask the dreaded question: 'Do you mean to say you've done nothing?' Should this happen, it is preferable to be able to say: 'Sir, we gave it some very serious thought and we even tried, but unfortunately...'.

26 April 1968, doc. 909970

At a short information briefing before lunch, the AEC had 33 different items on the agenda, ranging from UK views on a gas centrifuge to an official entertainment authorization (within which the staff would consider the possibility of an AEC–Department of State reception) to travel expenses for a Lawrence award medalist. Thule was item 18 on the agenda. The commission approved a brief underwater survey for weapon debris. This document was declassified as early as 1986.

2 May 1968, doc. 107032

This document is the study by Sandia Corporation that aimed to develop an estimated 'footprint' of underwater trajectories which could be of assistance in the search for a specific piece of weapon debris at Thule, a 'missing weapon part'. There is no word of any bomb.

Re: Results of Study to Determine Sea Floor Search Area for Missing Debris (U)

On April 4, 1968, AEC/ALO requested Sandia Corporation to assist in defining an underwater search area off the coast of Thule AFB, Greenland. A missing weapon part is presumed to be located in the area as the result of a recent B52 aircraft crash. This letter presents the results of theoretical underwater trajectory studies performed by Division 9324.

Physical characteristics of the missing objects:

Weight:
Length:
Diameter:
Spherical Radius of Ends:
Cross Sectional Area
Side on Area:

DELETED

Hydrodynamic characteristics of object:

Drag Coefficient (end on): 0.6
Drag Coefficient (side on): 1.0

We promised to return to the question of the characteristics of the missing object, and here we now go, despite being blindfolded by the deleted numbers in the above paragraphs.

First observation: it is neither a bullet nor a cube. These objects do not have length and ends. Second observation: we can deduce that it is a cylinder with rounded ends. It has length and a spherical radius in both ends, and the cross-sectional area is circular, since the cross section has a diameter which is the same at both ends of the object.

As to the hydrodynamic section, the lower the drag coefficient (*strømningsmodstands-koefficient*), the better the hydrodynamic characteristics of the object. Reference works say that a penguin has a drag coefficient of 0.03, a smooth sphere has a drag coefficient of 0.1, a rough sphere a drag coefficient of 0.4, a cone 0.5, a long cylinder 0.82, a cube 1.05, and a short cylinder 1.15.

Thus, Sandia's drag coefficient for the object (end on) of 0.6 would seem a near fit for a long cylinder with rounded ends.

As we have shown elsewhere, a good deal of effort was spent in recovering pieces of oralloy/uranium-235 from the secondaries. The reader may also recall that Dr Chambers, in his interview with the BBC, was speaking about 'the radioactive material'. The reference value for nuclear weapons of this generation is about 2 kg of plutonium and 16 kg of uranium 235. In order to reach the sufficient amount of fissile material in the primary pit, we surmise that roughly 8 kg of uranium were needed as part of the primary pit (Albright et al. 1993. The presence of U-235 in the primaries of the concrete weapons has been known since the first release of DOE documents in 1994 and has been confirmed by Eriksson 2002, 2008, and by Nielsen & Roos 2006). This guess leaves 8 kg of uranium 235 for the fissile core of the secondary stage. Another indication is the 20-pound section, which was mentioned under 24 February (doc. 106887).

Against this background, we can allow ourselves a few conjectures. If the cylinder were a compact uranium rod, representing the so-called spark plug or fissile core of the thermonuclear secondary stage of the weapon, and if the amount of uranium were 8 kg and its density 19.1 g/cubic centimetre, then the volume of the cylinder would be approximately 419 cubic centimetres, less than half a litre. We should emphasize that we do not know the actual amount of uranium 235. What we have are merely indications.

If this volume were distributed in a solid cylinder with a diameter of 3.3 centimetres, then the cross-sectional area would be 8.55 square centimetres and the length of the cylinder would be about 50 centimetres. We may add that uranium is a little softer than steel: it is malleable, ductile and slightly paramagnetic. What is more important, crumbling of uranium metal during corrosion in water has been observed in many studies.

Lest the reader believe that we think the decimals are important, we had better say that it is of no importance for the argument whether the diameter is 3 or 7 or any other figure. We should also leave open other possibilities. For instance, the spherical ends of the cylinder may have formed part of an external casing of the uranium. If this casing were part of the wanted cylinder, the dimensions would be somewhat larger.

Why would a uranium rod have spherical ends? Could it have something to do with the rod being hollow, in other words a pipe, and that the rounded ends were a convenient or solid way to close the pipe? Or was there some other reason for this sealing of the rod? Was it to make sure that the radiation pressure on the pipe would only be exerted from the outside? A metallurgist, chemist or physicist might answer this question. It is often mentioned in the literature that the spark plug could be hollow, and this is in fact the most likely scenario.

In doc. 107047, which discusses recovered pit pieces, almost certainly from secondaries, the wall thickness of the pieces is discussed several times. This would seem to indicate that the uranium pit was indeed hollow. We would not be surprised if the uranium/oralloy pipe were designated by the term 'secondary pit' in excised parts of the documents, although we cannot substantiate this assumption with evidence from the literature or interviews.

Since we do not know the construction details, we must obviously also allow for the possibility that the uranium cylinder was kept in some form of casing. Still, the uranium cylinder would be the prize.

For those who are mainly interested in the external dimensions of the spark plug and thus the chances of spotting it, the pipe would obviously be a little thicker and more visible than the solid rod. If we use the same values as above but assume an external diameter of 5.4 centimetres and an internal diameter of 4.3 centimetres, the length of the pipe would again be roughly 50 centimetres, whereas the wall thickness would be 1.1 centimetres. Again, this is based on conjecture and a few indications only.

It would not have been an easy task to find such a small object on the sea bottom under any circumstances. Furthermore, we should remember that, although the Americans were looking for the whole object – the description of an object with two spherical ends tells us that – they would also have to allow for the possibility of finding only a part of such an object, or that it could have been broken up into even smaller pieces. These could have been overlooked in the ice and snow on the surface, or been scattered among thousands of pieces of small aircraft debris on the sea bottom, or in fact already been partially collected on the surface. A small object, yes, but bigger than a spark plug in a car. We have chosen to call it the marshal's baton instead. The size fits better.

If such a small object really did fall to the sea bottom, there is little chance of it being visible and distinguishable in the side scans performed in Bylot Sound in 2003 by the Geological Survey of Denmark and Greenland (GEUS 2003). In fact, it would have crumbled long ago.

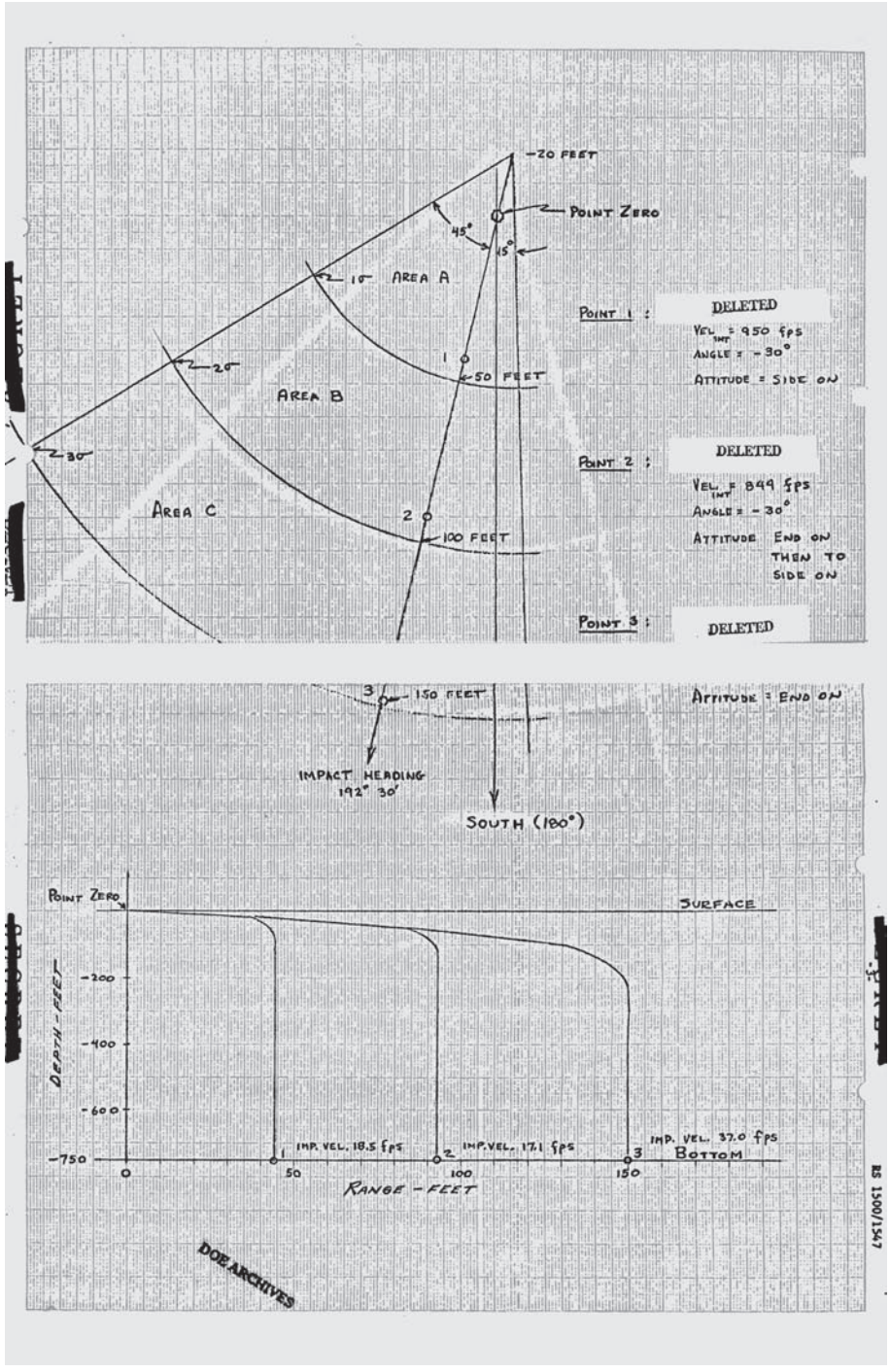
The sedimentation rate on the bottom is 2-4 mm per year, that is, 8-16 cm during the forty years since the accident. The new sediment has been efficiently mixed into the old layer through biological activity (Dahlgaard et al. 2001).

According to the sketches below, Sandia Corporation believed that the object might be found on the sea bottom somewhere between 50 and 150 feet from the impact point. These possible locations were based on various assumptions about the object's original velocity, impact angle and attitude in the water: side on or end on?

As it will be recalled, doc. 107036 mentioned the eventuality that a foreign nation might recover the object if the Americans did not do it themselves. It is hard to believe that this was really a very serious concern, and the relaxed atmosphere of the documents speaks against it.

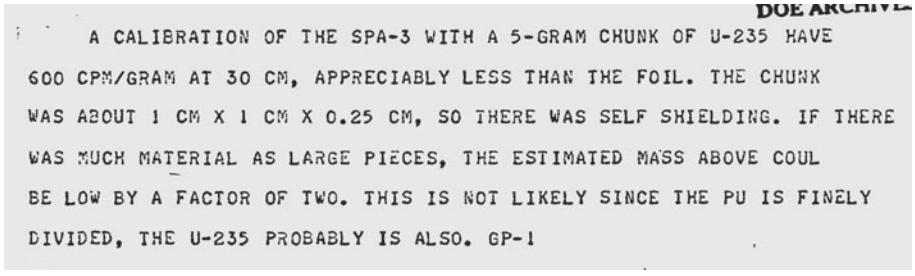
First of all, the object was of relatively minor importance in the perspective of the decision-makers. Secondly, the risk that the Soviets should be snooping around for it and actually find it was in every sense of the word very remote and thus a risk worth taking if need be.

Having determined the likely identity of the missing object, we can now move on to some of the documents concerning the search operation. But first we must introduce an additional piece of information about the state of the fissile material from the primary pits.


-20 FEET
POINT ZERO
45°
15°
15 AREA A
25
AREA B
30
AREA C
1
50 FEET
2
100 FEET
POINT 1 :
DELETED
VEL INT = 950 fps
ANGLE = -30°
ATTITUDE = SIDE ON
POINT 2 :
DELETED
VEL INT = 849 fps
ANGLE = -30°
ATTITUDE END ON THEN TO SIDE ON
POINT 3 :
DELETED
3
150 FEET
ATTITUDE = END ON
IMPACT HEADING 192° 30'
SOUTH (180°)
POINT ZERO
SURFACE
DEPTH - FEET
-200
-400
-600
-750
IMP. VEL. 18.5 fps
IMP. VEL. 17.1 fps
IMP. VEL. 37.0 fps
BOTTOM
0
50
100
150
RANGE - FEET
DOE ARCHIVES
RS 1500/1547

28 May 1968, doc. 107016
Telex from James [Jim] L. Olsen, Livermore.

Olsen reports about surveys of fissile material on aircraft parts in Crested Ice containers. All the barrels had been surveyed externally using a SPA-3 set on 185 keV. The fissile material was assumed to be uniformly distributed through the barrels. This fissile material is derived, we think, exclusively from the explosions that dispersed the contents of the primary pits. We learn that the plutonium on the airplane parts is finely divided and that the same is probably the case with the uranium 235.


DOE ARCHIVE

A CALIBRATION OF THE SPA-3 WITH A 5-GRAM CHUNK OF U-235 HAVE 600 CPM/GRAM AT 30 CM, APPRECIABLY LESS THAN THE FOIL. THE CHUNK WAS ABOUT 1 CM X 1 CM X 0.25 CM, SO THERE WAS SELF SHIELDING. IF THERE WAS MUCH MATERIAL AS LARGE PIECES, THE ESTIMATED MASS ABOVE COUL BE LOW BY A FACTOR OF TWO. THIS IS NOT LIKELY SINCE THE PU IS FINELY DIVIDED, THE U-235 PROBABLY IS ALSO. GP-1

Based on the findings in recent years of hot particles in the sediments in Bylot Sound with homogeneously integrated uranium 235 and plutonium, the question arises as to whether this integration of the materials had already taken place as bonding in the production process. To a layman, the account above indicates that the primary pit was a normal composite pit.

The composite pit had several advantages over using the materials separately. A single design could be used, employing both the available weapon materials. Using uranium 235 with plutonium reduced the amount of plutonium and thus the neutron background, and it also required a smaller critical mass than if uranium 235 were used alone.

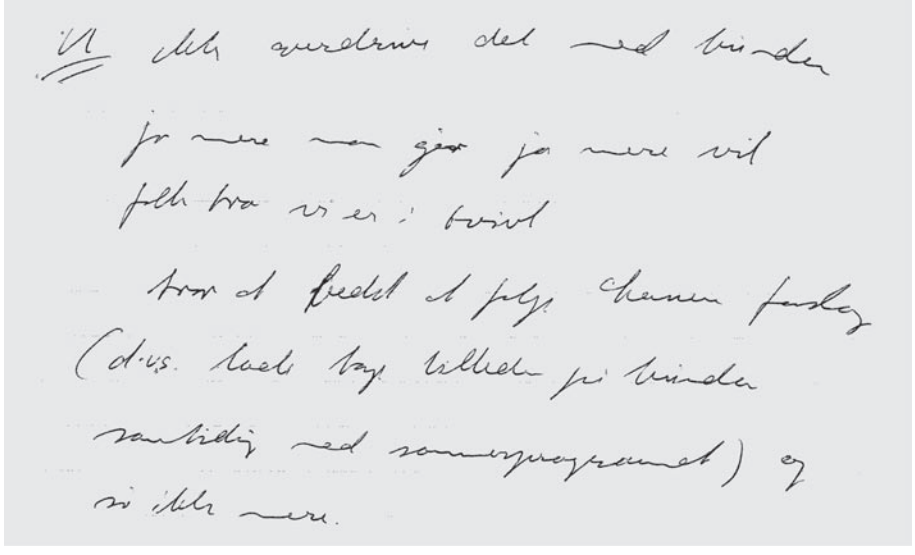
The scientists doing the monitoring in the area can tell us if this indication is of relevance for their work.

It is now more than twenty years since this document was declassified with deletions. It might be time for a new security review of the large excised part of the document, along with the final report on the amounts of fissile material on all recovered parts of the aircraft.

28 May 1968, AEK 28/5 1968
At a meeting in the Danish Atomic Energy Commission with H.H. Koch and Carl Walske as the top negotiators and ten further participants, the main topic was the 'ecological summer programme', that is, monitoring and final clean up.

Concerning the 'underwater research business', Walske said that this would probably be decided in the following week, that it was to some degree an financial problem (a cost of 200,000 dollars), and that it might not be necessary. One of the Danish participants, trying to be helpful, suggested that it might be possible to include some sea bottom photography in the Danish summer programme.

Walske answered that he would consider that seriously, while Koch commented that there was no reason to exaggerate the sea bottom thing. 'Jo mere man gør, jo mere vil folk tro vi er i tvivl' ['The more you do, the more people will think we are in doubt']. He considered it best to follow the proposal to include some photography in the summer programme, and that would be it. Walske said that he would discuss the matter back home.



6 June 1968, doc. 107114
Letter from Chairman Seaborg of the AEC to Carl Walske, DoD, concerning underwater search. Seaborg recommends that 'any bomb debris which is located should be retrieved this summer', that is, 1968. The deleted lines probably contain

a reference to the possibility that a missing weapon component could eventually be located on the sea bottom.

Dear Carl:

DELETED

we have considered the desirability of an underwater search of the area. We understand that the DoD is currently studying such a search. The AEC considers it important that a search be conducted to ascertain the extent of debris on the bottom in the vicinity of the crash area. Any bomb debris which is located should be retrieved this summer.

The chairman's direction to retrieve bomb debris would not be easy to follow if big pieces had been located. The submersible was not capable of any large-scale recovery operations. It was equipped with a mechanical arm fitted with a claw and could recover small pieces of perhaps up to 20 kilograms.

2 July 1968, doc. 107107
Message from James L. Olsen, Livermore, California, to among others Ray Stone at DMA, AEC in Washington, Wright Langham at Los Alamos, Colonel Montoya at SAC HQ at Offutt AFB, Nebraska. James Olsen asks Ray Stone to retransmit the message to one of the team chiefs, a lieutenant colonel working with Project Crested Ice in Thule.

The message recommended various methods of data collection for metallic objects that could turn out to be uranium pieces. Again we hear about the SPA-3 probes that could be submerged to the objects from a helicopter in order to identify them. The probes could be set to an upper level ratio of 3.3 and a peak response of 185 keV, which, we now recall, is the footprint of uranium 235. Twice the report mentioned uranium 238. We do not know what to do with this information. It is hardly a misspelling for 235, but might be an attempt to conceal the real purpose for somebody.

The document recommends two other methods of data collection as well, namely to carry out a thorough and continuing photographic programme on the broken ice area until it disappeared, and to obtain infrared photographs from the same area. All of these recommendations reflect an ongoing effort to collect radioactive pieces of the weapons. The hunt for the marshal's baton was still on, this time from both

boat and helicopter. The heat signatures of radioactive objects depend on their half-life. Thus the heat signature of plutonium would be stronger than that of uranium by a factor 30,000. The chances of finding the marshal's baton or its fragments in the brash ice by infrared imagery were probably small.

18 July 1968, notits 18/7 1968

This document is a short Danish summary of a meeting that took place at the Danish Atomic Energy Commission. The participants were the chairman of the commission, Under Secretary of State H.H. Koch, Major General Glasser, U.S. Air Force, Gjørup from Risø, two officials from the U.S. Embassy in Copenhagen, and two secretaries from the Commission and the Danish Ministry of Foreign Affairs.

At the meeting, General Glasser announced that it had been decided to undertake a photographic survey of the sea bottom in a circular area with a radius of 100 metres from the impact point. This would be done with a small submersible that would make daily diving expeditions over a week in August. The submersible would not be capable of any recovery operations. Close, but no cigar. As we have just learned, Star III did indeed have a very limited capability for recovery operations, but only for small objects of perhaps up to 20 kg, as was the case for Star II.

This fact was, on the other hand, no big secret. It was common knowledge on the base, and furthermore, the joint Crested Ice report has a fine picture showing Star III in Thule, with the claw used for small recovery operations clearly visible under the nose section. The reader will find a collection of photographs on the website of the report, showing the claw in action at the bottom of the sea. Walske sent these pictures to Koch, and they are now at the Danish National Archives.

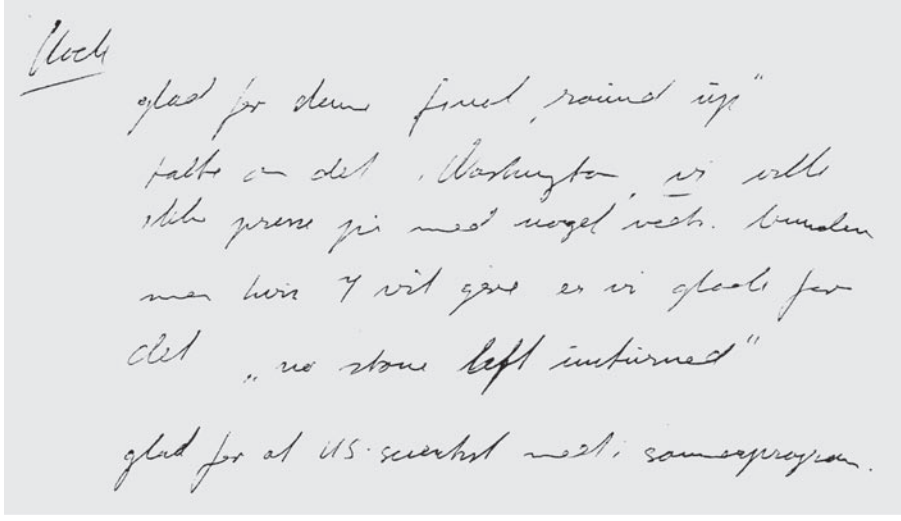
The Danish Atomic Energy Commission and General Glasser were in agreement that the surveys and clean-up operation that had already been performed made it highly unlikely that the pictures would give any indications that there was any airplane wreckage or fragments of nuclear weapons on the sea bottom.

It would be rash to guess about the possible details and doubts behind this professed agreement. Let us confine ourselves to the obvious fact that, in the summer of 1968, Danish and U.S. officials discussed the possibility of aircraft and weapons residue being on the sea bed. This was part of a continuing discussion between them that had started several months earlier in Washington, and the eventuality of such a search had been put in writing in the 'Gentlemen's Agreement'.

The question as to whether the Danes might have been told informally that the submersible would be looking for a small uranium rod is in our opinion not of overriding importance. It would be quite another matter had the Americans suspected that there were plutonium components on the sea bed, not to speak of a whole bomb. If such an unofficial announcement had indeed been made, and we emphasize that we are not aware that it was, it would most likely have had a reassuring effect and been perceived as confirmation that no bombs had been left behind.

18 July 1968, AEK 18/7 1968

According to the AEK's hand-written minutes of the meeting, H.H. Koch commented that the search was a very useful step to make in order to make sure that nothing of importance was left on the sea bottom, and that the Danish side was grateful for this extra effort (AEK 18/7 1968).



Koch also said that he was satisfied with this final effort. It had been discussed in Washington, and the Danish side was not going to press the issue of a bottom survey. If, however, the Americans were to do it, the Danish side would be happy with that, since it would mean that no stone was being left unturned. ['..., vi ville ikke presse på med noget vedr. bunden men hvis I vil gøre det er vi glade for det'.]

H.H. Koch had more than sufficient information to understand that the bottom survey was not a major operation. He was in fact reassured by the dual signal of the American decision. The small dimensions of the survey allowed him to conclude that

there was no big bad wolf under the surface, and the fact that the survey was being performed after all was an extra guarantee that as much potentially harmful debris as possible had in fact been removed.

Context, Mr Corera! Use of sources from both parties when analyzing bilateral relations, Mr Corera! And, Mr Corera, inconvenient though it may seem, even use of sources in strange languages from countries not enjoying the unspeakable fortune of being partners in the Anglo-Saxon media orbit.

The main constituent in the Danish handling of the case was a concern for the elimination of as many of the consequences of the accident as possible. This chief concern was accompanied by carefully balanced efforts of crisis-management with the goal of establishing the necessary safety regulations on the one hand and avoiding panic on the other. Finally, the Danes respected the secrecy concerns of the American side as long as they were not felt to interfere seriously with their own main concerns.

The cross-pressures and apparent paradoxes arising from considerations of secrecy, foreign relations, crisis management, and public diplomacy are not unusual in the handling of such cases. They may to some extent be bridged with instruments from the tool-box of diplomacy such as the cultivation of confidence and cordial relations between main negotiators. This was well understood by H.H. Koch and Carl Walske. These features are trivial and can easily be described in a newspaper article. However, they are admittedly not fit for journalistic stand-up bravado in distant locations.

Mr Corera's fairy tale should not deflect attention away from what is relevant today, namely the continued monitoring of the effects of the accident. With equal measures of professionalism and common sense, H.H. Koch and Carl Walske succeeded in finding mutually acceptable solutions in a difficult situation in which Danish-U.S. relations had to be handled under the conflicting pressures of creating a durable diplomatic solution to the question of the U.S. nuclear presence (absence) from the skies of Greenland, and the clean-up operation after the Thule accident. Thinking along stochastic lines, it was not to be expected that the same degree of professionalism in handling matters pertaining to the accident would endure over the next four decades without occasional aberrations.

27 July 1968, doc. 107095

Telex from the Chief of Staff of the Air Force (CSAF) that the underwater operation had been authorized and was ready to begin. This was declassified many years ago, in 1991.

The main part of the telex was about the operational requirements. The confidential nature of the fact that the operation included a search for an object or weapon part can hardly come as a surprise to anybody. There were many good reasons for this. The same was said in doc. 107113. Referring to the extended diplomatic prehistory of the underwater operations, we may tell the BBC journalist on the quiet that his sensational assertion about the Danes not being informed as to the real purpose of the dives is about as far from the reality as Oxford is from Thule.

It is difficult to see why an astute observer such as Mr Corera, who has written extensively on the British and American intelligence community, would base such misleading assertions on one or two U.S. Air Force documents and fail to take into account the hierarchical and compartmentalized nature of confidentiality and secrecy in foreign relations.

As we have noted already, it is slightly disconcerting that a journalist who takes such apparent interest in archival research that he has requested 348 documents from the DOE archive in Nevada and has been sleeping with them under his pillow for seven years has been unable to locate the Danish National Archive on the map. It is somewhat puzzling that he finds it possible to pass judgment on the bilateral relations of Denmark and the U.S. concerning the underwater operation exclusively on the basis of a few American documents, generated outside the main negotiating circuit.

24 August 1968, doc. 107074

We now return to Thule, where the diving operations had started in August. Eleven dives were performed, with an average of three hours productive survey time per dive (Crested Ice 1970, 95). Document 107059 differs by stating that actual search time per dive was only 1.5 hours. At the Danish government's request, the Americans handed over videotapes containing sixteen hours of footage from the dives in April and May 1988 (HIAS 1988).

This document is the daily situation report, with an account of dive number 7 of Star III. The situation reports, eleven altogether, were of low classification: 'For official use only'. As is evident from doc. 107072, which is analyzed below, there were also reports classified 'Secret'. We cannot expect to find any important information about sighted weapon parts in the daily situation reports that were classified 'for official use only'.

A circular area around the datum point was surveyed for a distance of 180 feet. Debris extended 'in a northerly direction from slightly south of the datum point to the 180 foot circle.' The concentration was 'quite heavy to the 120 foot circle' and appeared 'to decrease from the 120 foot to the 180 foot circle.'

'During this dive, two different red fabric bags were sighted' and an attempt made to recover them. This was the kind of recovery capability the submersible had. It is specifically mentioned in the document that the manipulator of Star III had been repaired and would be used in the attempt to recover the bags. The manipulator was a mechanical arm that could be fitted with various tools, in this case a claw. Those who have seen the videotapes from the dives can confirm that the claw did in fact work (HIAS 1988; cf. photos on www.diis.dk/thuleaccident).

TETHER LINE OVER IT ON EACH CIRCLE. THIS PROCEDURE WAS SUCCESSFUL DURING DIVE NR 7 AND CICULAR AREA AROUND DATUM POINT FOR A RADIUS DISTANCE OF 180 FEET WAS SURVEYED. EXCELLENT 35MM AND VIDEO TAPE PICTURES WERE OBTAINED. IT NOW APPEARS THAT DEBRIS EXTENDS IN A NORTHERLY DIRECTION FROM SLIGHTLY SOUTH OF THE DATUM POINT TO THE 180 FOOT CIRCLE. THE CONCENTRATION IS QUITE HEAVY TO THE 120 FOOT CIRCLE AND APPEARS TO DECREASE FROM THE 120 FOOT TO THE 180 FOOT CIRCLE. DURING THIS DIVE TWO DIFFERENT RED FABRIC BAGS WERE SIGHTED. AN ATTEMPT WILL BE MADE TO RECOVER THESE BAGS ON DIVE NR 8 THIS MORNING USING THE MANIPULATOR WHICH HAS BEEN REPAIRED.
3. AFINS OBSERVERS NOW ESTIMATE THAT ABOUT 45 PCT OF THE REQUIRED AREA HAS BEEN SURVEYED. WE ARE GETTING GOOD RESULTS FROM BOTH 35MM AND VIDEO NOW. TWO MORE MISSIONS AS PRODUCTIVE AS NR 7 SHOULD COMPLETE THE JOB.

26 August 1968, doc. 107071
Daily situation report of dive number 9 of Star III on 25 August. We notice that two areas within the debris pattern contained heavy pieces of landing gear and structural members of the aircraft. These areas were located 50-100 feet and 150-200 feet from the datum point.

2. STAR III WAS LAUNCHED FOR OPERATIONAL DIVE NBR 9 AT 1030 ON 25 AUG 68 AND SUBMERGED AT 1310. THE SURVEY AREA WAS EXTENDED FROM 195 TO 240 FEET DURING THIS DIVE. STAR III RETURNED TO THE DOCK AT 2020. THE ONLY DIFFICULTY ENCOUNTERED WAS FOULING OF THE TETHER LINE, NOT UNEXPECTED AT SUCH RANGES FROM THE DATUM POINT BUT CAUSING DIVE TO TERMINATE AT 1735. DEBRIS PATTERN DESCRIBED IN PARA 2, REPORT NBR 23 IS STILL VALID. TWO AREAS WITHIN THE DEBRIS PATTERN CONTAINED HEAVY PIECES OF LANDING GEAR AND STRUCTURAL MEMBERS ABOUT 50 TO 100 FEET AND 150 TO 200 FEET FROM THE DATUM POINT. DEBRIS BEYOND 200 FEET IS GENERALLY SMALL, WIDELY SCATTERED AND SOME IS RUSTING OR CORRODING. ALL IS STABLE OR EMBEDDED IN THE BOTTOM AND MANY PIECES ARE BEING

27 August 1968, doc. 107070
Daily situation report of dive number 10 of Star III. The findings of this dive included medium and heavy aircraft debris, this time at the 255 foot distance SSW of the datum point, and generally between bearings 170 degrees and 210 degrees.

2. STAR III LAUNCHING FOR DIVE NBR 10 WAS DELAYED UNTIL 1105 HOURS 26 AUG 68 WHILE NEW TETHERING LINE WAS RIGGED. THE BOAT SUBMERGED AT 1333 AND MADE ONE ORBIT AT A DISTANCE OF 255 FEET FROM THE DATUM POINT. WHILE POSITIONING FOR NEXT ORBIT, THE SUBMARINE CREW DETECTED THAT THE REFER-

ENCE ROPE LINE WAS SNAGGED IN ROCKS ON THE BOTTOM. THE
BOAT BECAME SNARED IN THE REFERENCE ROPE LINE AND HAD TO
SURFACE AT 1510 TO FREE ITSELF. IT THEN RETURNED TO DOCK
AT 2045. BOTH VIDEO TAPE AND 35MM PHOTOS WERE OBTAINED.
EXCELLENT 35MM PHOTOS WERE TAKEN OF SOME MEDIUM AND
HEAVY AIRCRAFT DEBRIS AT THE 255 FOOT DISTANCE SSW OF THE
DATUM POINT GENERALLY BETWEEN BEARINS 170 DEGREES AND 210 DEG.
DIVE NBR 11 WILL CONCENTRATE ON THIS ARC.

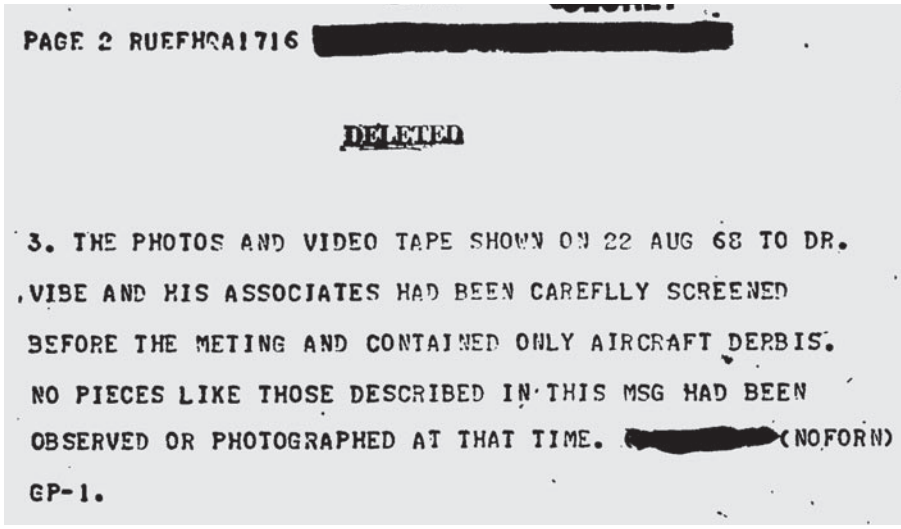
None of this heavy and medium debris was visible on the extensive side scan sonar surveys performed by the Geological Survey of Denmark and Greenland (GEUS) in 2003 (GEUS 2003).

27 August 1968, doc. 107072
This is a supplementary situation report, originally classified 'Secret' and for limited distribution only (limdis). As mentioned above, the daily sitreps were classified as 'Official use only' and did not contain any information about weapon parts of any importance sighted on the sea bottom.

We learn that two observers, air force officers from the Directorate of Nuclear Safety, taking part in the dives, had identified 'pieces of external and ballistic

1. THIS MESSAGE SUPPLEMENTS FOR LIMDIS THE INFO
REPORTED IN PARA NBR 2, CRESTED ICE REPORT NBR 25, SUBMITTED
26 AUG 68, OCEAN BOTTOM SURVEY. (U).
2. TWO OBSERVERS HAVE IDENTIFIED PICES OF EXTERNAL AND
BALLISTIC CASE SECTION [redacted] DURING DIVES NBR 8 AND
NBR 9 AND 24 AND 25 AUG 68. ONE EXTERNAL FLAT CABLE RACEWAY
WITH CONNECTIORS MISSING,

DELETE



PAGE 2 RUEFHQA1716 [redacted]

DELETED

3. THE PHOTOS AND VIDEO TAPE SHOWN ON 22 AUG 68 TO DR. VIBE AND HIS ASSOCIATES HAD BEEN CAREFLLY SCREENED BEFORE THE METING AND CONTAINED ONLY AIRCRAFT DERBIS. NO PIECES LIKE THOSE DESCRIBED IN THIS MSG HAD BEEN OBSERVED OR PHOTOGRAPHED AT THAT TIME. [redacted](NOFORN)

GP-1.

case section [deleted] during dives number 8 and number 9 of 24 and 25 August 1968.' They had also seen an 'external flat cable raceway with connectors missing', that is, without connectors. An extensive excision covers the remainder of the paragraph.

We are further told that the weapons parts mentioned here were the only ones observed during the dives.

There is nothing remarkable about the bracketed word '(noforn)' in the last line. As we have heard before, the Americans had a closed circuit for detailed information about 'secret restricted data' associated with found weapon components. It was fully consistent with this principle that Dr Vibe and his associates should not see pictures of the weapon debris.

Incidentally, a rich collection of unclassified pictures from the diving operations are preserved in the archival holdings of the Danish Atomic Energy Commission in the National Archives in Copenhagen (Rigsarkivet), and as already noted, sixteen hours of video footage from the dives have been handed over to the Danish authorities (HIAS 1988).

Methodologically, this case serves as a reminder that, in a situation in which 'secret restricted data' are involved, one will most likely not obtain the full picture by reading only documents of low classification. Not surprisingly, there are two

completely different stories of the dives in these few documents. Furthermore, there is always the possibility that there are documents to which one has no access at all. It is hard to know when and if one is seeing the whole picture. In this case, there may be a double or triple fence, first the excised part above, and then possibly a special report on the find in the excised part. It appears that we will have to wait a little while, before these classified parts and pieces of documents come down to us.

We will now pretend that this is the only information we have about this find. We do this merely to demonstrate the futile speculations to which excisions will sometimes lead the historian. Fortunately, after this small experiment with, as it turns out, its sometimes flawed speculations, at least a partial solution is at hand in the following doc. 107059, or rather in the attached sketch.

The external case section may be the outer case of the weapon, whereas the ballistic case section may be the part around the sealed portion, including the primary/fission trigger and the secondary/thermonuclear stage. If this is so, it begs the question whether this piece of the ballistic case section was in such a condition that some of its original contents remained.

The remark about an external flat cable raceway without connectors conveys the impression that the components to which the cable raceway had been attached were in pretty good shape. Moreover, the sheer size of the excised paragraph might lead us to believe that there was a good deal to say about this finding, whether it had turned out as expected or not.

This leads us to the next question. Given the amount of attention devoted to identifying and associating bits and pieces of the weapons found on the ice with specific weapons, were these pieces really not recovered in an endeavour to associate them with a specific weapon? Were they or the components of the secondaries that were found on the ice close to the impact point in such a condition that the possibility that they belonged to the same weapon as the pieces on the sea bottom could be ruled out? Or the other way round, when combined with what was known about the weapons components found on the ice, what were the indications that the finds on the sea bottom were part of, for instance, a third or fourth weapon?

Could these questions be answered simply by looking at the pieces under water and taking pictures? Or was the find in itself and the information contained in the excised

paragraph of such a character that it constituted one important last piece in the jigsaw – a piece in the jigsaw that alleviated some very residual worries possibly existing right up to this moment that 'secret restricted data' or objects of some operational significance might be hidden on the sea bottom?

We do not know the answer, but we can take note of the perhaps surprising ease with which the decision was taken to discontinue the operations of Star III. The fact remains that the diving season could have been extended for nearly a month more. If there had been a vital interest in prolonging the operations, bureaucratic difficulties or inflexible planning would hardly have prevented it.

Here ends the experiment in which we have pretended not to know the sequel.

It is quite obvious that the underwater operation at Thule was conducted with a much lower priority than the one in Palomares. When we compare the limited size and the decision to discontinue the diving operation in Thule with the extraordinary and successful efforts to recover the missing bomb in Palomares, we understand that they were extremely different in size and importance. This in itself should tell us that nobody was looking for a bomb.

The mere fact that Star III, with its very limited recovery capability, was chosen for the operation is another telling indication that the Americans were not looking for something as heavy as a bomb, neither the physics package (the primary and secondary stages), nor the secondary stage of a bomb.

10 September, 1968, doc. 107059
Tenth status report from General Giller to the Chairman of the AEC and the Commissioners. This is the last and most important of the documents concerning the search for weapon components on the sea bottom. It was originally classified 'Secret' and deals with the same events as the 27 August 1968 doc. 107072, but it has a good deal of supplementary information. Many of the questions raised by doc. 107072 of 27 August 1968 are answered by this document, but not all.

That said, this status report hardly tells us everything from the debriefing of the three Air Force officers in Dr Walske's office in Washington. The minutes of that debriefing have not come down to us, nor have the final reports on the results of the dives by the Directorate of Nuclear Safety and the CSAF.

The underwater search of North Star Bay was scheduled to terminate on August 25, 1968. However, in view of the marked improvement in performance of the submersible STAR III, coupled with reported observation of some small parts related to one or more of the weapons during the operations on August 24 and August 25, the Chief of Staff, U. S. Air Force, granted approval to extend the search through August 28, 1968. The last dive which was scheduled for August 28 had to be cancelled due to bad weather. Commissioner Tape, upon being informed by Dr. Walske that bad weather prevented a dive and all was about to be buttoned up for return, agreed not to try to reverse the proposed action. Dr. Walske also spoke to Major General Glasser of Headquarters, USAF. All agreed that further survey operations could be terminated. With the concurrence of the Secretary of the Air Force, the on-scene commander at Thule was then advised to cease operations, demobilize and return all equipment and personnel involved in the survey to the United States.

But first a few words about the decision process that is described in the first section of the document. After the observation of small weapons parts on August 24 and 25, the Chief of Staff of the Air Force had granted approval to extend the search through to August 28. However, the last dive scheduled for August 28 had to be cancelled due to bad weather.

We might see this as a sign that the commitment to find the object was not that high. The reason for this, we think, is that it was not considered of vital importance to find the missing marshal's baton. The decision of the Chief of Staff to extend the operation by one single dive sounds more like 'For Heaven's sake, then, take one last look!'

Similarly, Commissioner Tape from AEC, Dr Walske from DoD, and General Glasser from Headquarters U.S. Air Force agreed that the 'survey operations could be terminated. With the concurrence of the Secretary of the Air Force the on-scene commander at Thule was told to cease operations, demobilize and return all equipment and personnel involved in the survey to the United States.'

The whole atmosphere in which this matter was handled confirms our analysis that, although of some importance, the underwater operation in Thule was clearly not a high priority in the same league as the underwater operations in Spain. It was, in fact, a rather low key undertaking.

The well-tempered words of Dr Chambers to the BBC, that 'there was disappointment in what you might call a failure to return all of the components' conveys, we believe,

this relatively relaxed atmosphere. The denominator of relaxation in this sentence is especially the words 'what you might call a failure'.

If this had been a matter of finding a bomb, Chambers would clearly not have qualified the failure to bring it back as 'what you might call a failure'. His careful choice of words is strangely wasted on an otherwise qualified journalist, whose primary concern in this case seems to be to squeeze as much drama as possible out of the interview.

The small weapon parts were visually identified as pieces of the external and ballistic case section of a [redacted] weapon. No parts of a weapon secondary were observed, and none of the weapon-related parts have been recovered, nor do they show up in the photographs presently available.

DOE ARC

A briefing on the underwater survey effort was presented in Dr. Walske's office on August 31, 1968. The briefing was presented by the three U. S. Air Force officers who manned the STAR III during the operation. A total of 11 dives was made with an actual search time of approximately 1.5 hours per dive (longest dive was more than 3½ hours). Excellent photographic coverage has been obtained

Concerning the weapon parts, we are told that they were small and that they did not belong to any secondary. In the attached sketch, we read a more exact description. The external case section is described as a section of the steel polar cap (14 x 14 x 12 inches), while the other item was a section of the MC-706 warhead ballistic case (3 x 1½ ft). Apart from that, there were the external flat cable raceway that we heard about earlier, and finally a section of steel locking band (a six-inch piece).

The two case pieces were apparently empty or maybe flattened by the explosion of the HE. However, the polar cap was described in three dimensions.

which serves to better define the characteristics of the bottom of the bay and to present pictorial evidence of the type of aircraft debris which now rests on the bottom. In view of the fact that the bottom itself has a rather uniform hard surface which is covered by a light layer of fine silt, it has been concluded that most any debris which went through the ice would remain on the hard surface and would have been detected during the survey. Enclosed is a freehand sketch of a chart used by the briefing officers to show the concentrations of aircraft debris and the location of the four pieces of weapon-related parts. Concentrations "A" and "B" each consisted of some 3,000 to 4,000 small pieces of debris which were believed to have been trapped in the ice and then deposited as the ice shifted back and forth during the melting phase. Some of the debris in Concen-

tration "C" consisted of large, heavy pieces of the aircraft such as landing gear structures. The survey was terminated before the details and extent of Concentration "C" could be determined. During the briefing, considerable discussion was generated by the unexpected location of the heavy debris with relation to the impact point. It was further speculated that the missing [redacted] in view of its ballistic characteristics, may have come to rest beyond the observed concentration of the heavy debris.

Furthermore, an engine intake dust cover was recovered. This is recorded in the video footage, where the claw can be seen taking hold of the cover (HIAS 1988).

One piece of aircraft debris, a canvas (or canvas like plastic) engine intake dust cover, was recovered and contamination readings were taken. The wet reading was 1,500 CPM, and a later dry reading was made and recorded as ranging from 0 to 5,000 CPM over the entire surface of the dust cover with the high readings coming from points of impregnated radioactive material.

On the attached sketch, we have two concentrations of debris 'A' and 'B', each with 3,000 to 4,000 small pieces of debris. We are reminded of Professor Kofoed-Hansen's description that the B-52 had been blown into millions of pieces.

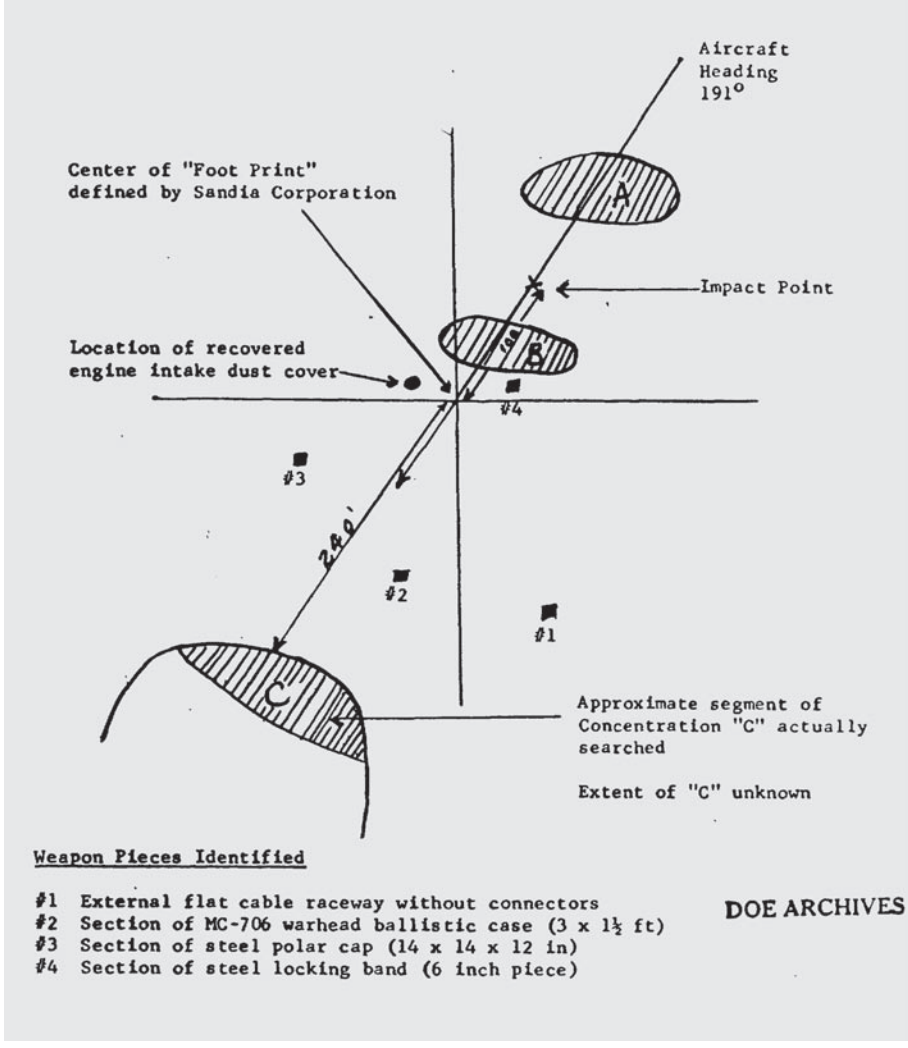
We cannot avoid speculating that, if our suspected uranium marshal's baton were among these many pieces of debris, it might have been rather difficult to find it within the very limited time frame. We can also make the more humble observation that the 'missing [word deleted] in view of its ballistic characteristics' is mentioned in the singular. This is as we expected.

Towards the end, the memorandum contains an interesting observation from the debriefing of the three Air Force officers. It turns out that considerable discussion was generated during the briefing by the unexpected location of the heavy debris in relation to the impact point. This obviously led to further speculation that, in view of its ballistic characteristics, the missing object might have come to rest beyond the observed concentration of the heavy debris.

Some of the participants in the briefing may have visualized the slender, heavy uranium cylinder with its spherical end shooting like an arrow through the water at high speed.

Confronted with the realities of the 'footprint' of the crash, not everybody seemed entirely convinced by Sandia's predictions based on estimated speeds, drag coefficients and all the other parameters involved.

Still we find it relevant to emphasize once more that, at the beginning of the operation, nobody could know whether the cylinder was actually there.



The document is, of course, correct when it mentions the four weapons-related parts on the sketch, but were there other weapons-related parts too? We still have

not found out what is hidden in the perhaps 6-8 lines of excision in doc. 107072 of 27 August.

It was a somewhat diluted version of the American dives that was presented by the base commander, Colonel C.S. Dresser, in the joint Danish-American report 'Project Crested Ice', published in 1970. 'During August, Danish and American scientists, using a 54-foot Danish motor launch MS AGLANTHA, and a 24-foot minisubmarine, STAR III, conducted repeated radiological surveys and ecological studies along the shores of Wholstenholme [sic!] Fjord to insure that no contamination remained in the area.' 'That's All Folks!' as they say at the end of cartoons, and as painted in large letters on the end of the last tank being shipped from Thule, as shown on a photo with Colonel Dresser posing in front. On the other hand, the article is to be commended for a fine picture showing Star III with the claw clearly visible under the nose section (Crested Ice 1970, 30f).

The reason we suspect that General Giller's status report does not tell us everything about the briefing in Dr Walske's office is that there is no mention of the find that is excised in doc. 107072. The video tapes that show the recovery of the engine dust cover also reveal the conspicuous interest of the Star III observers in elongated objects approximately 50 centimetres long. First they zoom in on a piece of flat iron with screw holes, roughly half a metre long, but then pan away. Later, the claw of the submersible removes an object which is hardly more than half a metre long. Apart from the engine dust cover, there are no other recovery attempts on the videos (HIAS 1988).

This remarkable behaviour appears to be consistent with Sandia's description of the missing weapon component and thus represents a further piece of evidence that we were probably on track in our analysis of the object on the basis of document 107032, and that this was the kind of object the Americans were looking for. However, on the basis of the available evidence it seems likely that, on closer inspection, the recovered piece turned out not to be the sought-after cylinder of uranium 235.

We said a little while ago that we did not know what is hidden in the perhaps 6-8 lines of the excision of doc. 107072 of 27 August. Could it be a discussion of the wanted object, the cylinder, that had been recovered, only to be discarded again as not being the real thing?

If this object had indeed been the prize, there would hardly have been a remark in document 107059 to the effect that no parts of a weapon secondary were observed.

Likewise, there would have been no reason to speculate during the briefing that 'the missing [word deleted] in view of its ballistic characteristics, might have come to rest beyond the observed concentration of the heavy debris.'

This concludes our survey of the documents generated in the course of the clean-up operation in Greenland.

Before we leave this part of the report, however, we should consider a document from 1969 which contains an estimate of the amounts of plutonium contained in the tanks and containers that were shipped to the Savannah River facility.

9 June 1969, doc. 107117
The document is a cover letter to a memorandum by General Giller dated 5 June 1969. The clipping below is from Giller's memorandum.

The memo is about the contents of the containers with snow and ice from Thule that were being processed at Savannah River. On 2 and 3 September 1968, 315 1,800 gallon tanks had been sent from Thule to Charleston, S.C. (doc. 107059). By 5 June 1969, 225 of these 315 jet engine containers with contaminated water had been processed. The filtrate called solid debris had been measured for its content of plutonium 239. The plutonium content in the solid debris was estimated to be from 2.2.kg to 3.9 kg.

The major reduction results from tests and experience which show that the liquid contents have very little plutonium and may be discarded to the seepage basins after filtration. Original cost estimates were based on evaporating the liquid. The safeguards against release of radioactive materials are equivalent to those which would have been provided had the liquid been evaporated. To date, liquid from 225 of the 315 jet engine containers has been processed satisfactorily, and the engine containers buried. Processing, with direct discard of the filtrate, is continuing at a rate of about five jet engine containers per day. Based on the current schedule, the anticipated completion date is September 1, 1969.

Measurement of the residual plutonium 239 has been accomplished and the plutonium content in the solid debris is estimated to be from 2.2 to 3.9 kg. The estimated plutonium content of all the liquids is less than 10 grams.

The most plausible reading would be to understand the last paragraph as giving an estimate of the plutonium contents in all 315 containers, although a small doubt remains that what is meant is not an estimate of the total contents but of the actual plutonium contents in the 225 containers. It can reasonably be assumed, though, that Savannah had more accurate figures on the debris that had already been processed and that they would not have used the word 'estimate' if those were the figures that were meant here.

Additionally, considering that we are high up in the bureaucracy, the most likely conclusion is that they are interested in aggregate numbers, not partial results.

We have thus chosen the former interpretation, which we think is the more convincing. The figures are very close to those agreed between Danish and American scientists after on-site measurements in Thule in 1968.

It is, in other words, of only marginal significance whether we use these figures or the on-site estimates in our calculation of the total plutonium burden in Chapter 5 and the appendices.

The Savannah figures serve both as a confirmation of the original on-site estimates of the plutonium spread on the ice and snow pack, and of the fact that this plutonium had been brought back to the United States.

Still, it would be relevant to have access to Savannah's final report with the measurements of the actual plutonium content in the debris from all 315 containers once the process had been completed around 1 September 1969.

4. The Palomares accident, 1966: state of the bombs and the fissile material

In order to illustrate what can happen to nuclear weapons in an accident, we have found it useful to bring in a few facts about the Palomares accident. In some respects the accidents are similar in that they involved the same type of plane and the same kind of bomb. But there are differences as well. In Palomares, the bombs were released from the plane before the crash, some of them with their parachutes unfolded, whereas in Thule the bombs were in the aircraft when it crashed. In Thule, parts of the bombs were exposed to the large-scale fire of jet fuel, whereas this was not the case in Palomares.

There had been nine nuclear accidents before Palomares in which the high explosive (HE) in the weapons exploded. However, the contamination from these earlier accidents had been low in radioactivity and highly localized in the areas affected. All these accidents stimulated the development of an insensitive high explosive (IHE), which possesses a unique insensitivity to extreme, abnormal environments, and of fire-resistant pits (FRPs) designed to reduce further the likelihood of plutonium dispersal in fire accidents (Gregory 1990: 32; Drell and Peurifoy 1994: 298-9, 301, 306-11; OTA 1993).

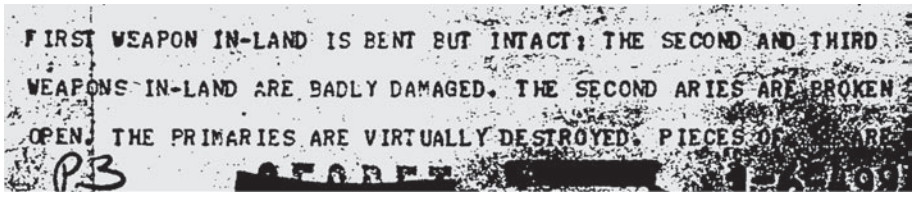
IHE can be impacted into rigid targets at velocities exceeding 1500 feet/sec without provoking the release of considerable chemical energy. Traditional explosives release most of their chemical energy on impact at velocities in the order of 100 feet/sec. It is generally assumed that the detonations in Palomares would not have occurred if the warheads had been equipped with IHE. This new type of explosive was first introduced into the stockpile in 1979 (Drell and Peurifoy 1994: 308-9).

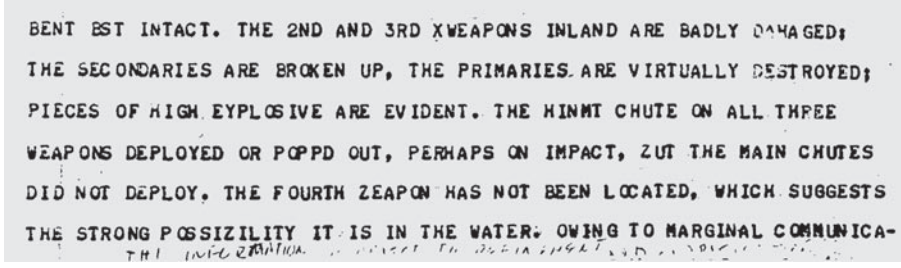
20 January 1966, doc. 1-6-4995. Cable to, among others, Sandia. Preliminary report of nuclear accident.
In this preliminary report, we learn about the three weapons that were found on land. The last bomb was later recovered from the sea bottom in a high priority operation.

The first weapon was found to be 'bent but intact'. The second and third were 'badly damaged. Their secondaries are broken open [and] the primaries are virtually

destroyed.' This was the result of a low order explosion of only parts of the high explosive (HE) in the primaries.

In contrast to Thule, pieces of unexploded HE were recovered from the site. In other words, even a partial low-order explosion in the primaries was sufficient to virtually destroy them and disperse the fissile material in the pits. This can readily be seen from the contamination patterns, which in some respects bear strong resemblance with what we see in Thule.


FIRST WEAPON IN-LAND IS BENT BUT INTACT; THE SECOND AND THIRD
WEAPONS IN-LAND ARE BADLY DAMAGED. THE SECOND ARIES ARE BROKEN
OPEN. THE PRIMARIES ARE VIRTUALLY DESTROYED. PIECES OF
P3


BENT BST INTACT. THE 2ND AND 3RD XWEAPONS INLAND ARE BADLY DAMAGED;
THE SECONDARIES ARE BROKEN UP, THE PRIMARIES ARE VIRTUALLY DESTROYED;
PIECES OF HIGH EYPLOSIVE ARE EVIDENT. THE HINMT CHUTE ON ALL THREE
WEAPONS DEPLOYED OR POPPD OUT, PERHAPS ON IMPACT, ZUT THE MAIN CHUTES
DID NOT DEPLOY. THE FOURTH ZEAPON HAS NOT BEEN LOCATED, WHICH SUGGESTS
THE STRONG POSSIZILITY IT IS IN THE WATER. OWING TO MARGINAL COMMUNICA-

The *Report Broken Arrow, Palomares, Spain*, on http://www.dod.mil/pubs/foi/reading_room/133.pdf, has the following account of the three weapons on land.

Weapon no. 1. This weapon was essentially intact. The tail closing plate tore off during breakup of the B-52, thereby deploying the pilot chute. The bomb nose had a 9-inch gash and was depressed slightly inward from impact. Three of the four fins were torn away. The ready-safe switch was found indicating 'Safe'. The weapon loading lugs were still engaged in the release rack mechanism.

Weapon no. 2. The high explosives (HE) had experienced a low-order detonation. The bomb secondary was found in s crater about twenty feet in diameter and six feet deep. A damaged but intact reservoir was found 25 feet from the crater. The broken afterbody and parapacks were found about 100 yards from the impact point. The Mild Detonating Fuse (MDF) had functioned, presumably

on impact, and the pilot chute was [unreadable word]. The main chute was out of the ruptured afterbody case; however, it was still in the chute bag. Firing components and quantities of unburned HE were recovered in small pieces. There was plutonium contamination in the area. No tritium indication was obtained with the T-290 tests.

Weapon no. 3. The HE in this weapon also experienced a low-order detonation. Quantities of unburned HE were recovered. The secondary was in a crater which measured about [unreadable figure] feet in diameter and 3 feet deep. The smashed reservoir was found 500 yards from the impact point. The afterbody was fairly intact with the main chute inside. The tail cover plate had apparently been torn off during break up of the aircraft and the pilot chute deployed. The pilot chute was partly burned, allowing this weapon to descend faster than No. 1. There was plutonium contamination in the area.

Supplementary information about the weapons involved in Palomares can be found in a short article by the Engineering and Analysis Division, Directorate of Nuclear Safety, in USAF Nuclear Safety, September – October 1966 (Broken Arrow Aftermath. 1966: 2-6).

For our purposes, the first remarkable feature about the Palomares accident is the fate of weapons no. 2 and 3, which experienced a low-order explosion of only parts of the HE. In both these cases, the primaries were virtually destroyed and the uranium 235 and plutonium 239 of the primary pits dispersed in particulate form, as witnessed by the pattern and intensity of the contamination.

It has been shown in experiments and in the literature that, after accidents involving explosions and fire, the fissile material in the pit of the primary stage will be dispersed in a particulate form. In a release of this kind, the particle size will be lognormal distributed, i.e. the relatively few large (hot) particles will carry the majority of the mass (activity). One consequence of such a release is that the activity distribution will be very heterogeneous, but it will also be very difficult to do representative sampling (Eriksson 2005).

We consider the agreement between the circumstances and the particle studies in Palomares and Thule to give a strong indication that the four primaries in Thule ended up in much the same way as the two exploding primaries in Palomares, that is, that the two cases had the HE explosions in common.

In Thule, this appears even more likely than in Palomares because the impact velocity of the weapons was much higher. Besides, in Thule we also had a large-scale fire. The explosions in Thule were apparently high-order. Langham's reconstruction might point in the same direction (107032, 107038).

The other remarkable feature about weapons 2 and 3 in Palomares is that, although the primaries were destroyed by the low-order explosions, recovery of the two secondaries was possible, albeit in a broken or damaged state. In particular, we may note that the tail section of the weapon with the parapack and the tritium reservoir seemed to be a weak point in the construction.

The recovery operation in Palomares was on an infinitely larger scale than the underwater operation in Thule (see doc. 107036, annex 1). This fact serves as yet another very good indication that the underwater operation in Thule was not about a nuclear weapon, a bomb, but something much smaller and less important.

In Palomares, perhaps more than 100 scuba divers searched the shallower parts, a cub submarine took the medium depths, and two-manned underwater craft, one called Alvin and the other Aluminaut, searched the deep water. The weapon was located some three weeks later by the Alvin. Once the weapon was located, a new unmanned underwater vehicle, the Curv, was used. The Curv was completely automated, with large crab-like pinchers, TV cameras and floodlights. The bomb was recovered on 7 April 1966, 80 days after the accident (doc. 107036).

5. Summaries: estimates of recovered weapons parts and the plutonium balance sheet

Estimates of recovered weapons parts

A total estimate of recovered weapons parts is not available because most of the relevant documents are still classified or sanitized. Yet, for our purposes some important data and interpretations can after all be squeezed out of the accessible sources.

We will not attempt in this chapter to present a list of the recovered weapons components that we have been discussing in the preceding pages. Instead we will concentrate on some features that stand out as particularly important in this regard, such as parts recovered, parts not recovered and questions of interpretation. We will discuss these features in the following order, dictated by the three main sections of the weapons: tail end, secondary, and primary.

In the background, behind this analysis and, we think, in most cases mercifully hidden from the reader's eye lies a combination of various methods, for instance, analyses of the decision-making in Copenhagen and Washington; analyses of the finds and no-finds of weapons components; assessments of the type and amount of fissile material in the primaries and the secondaries; a comparison with similar accidents, especially that in Palomares; and use of the auxiliary sciences of history on the documents, the archives, the bureaucratic process and other circumstances.

The tail ends. To take the most obvious first, it is incomprehensible that, for some years now, those who have claimed that SN 78252 had come to rest on the sea bottom have failed to recognize the simple fact that one of the vital parts of this particular bomb, the tritium reservoir, was accounted for early in the search operation and identified with it. This piece of evidence is enough to tell us that all four weapons broke up. The tritium reservoirs were placed in the tail ends of the weapons, but served the purpose of boosting the fission process in the primary stage of the weapons. This takes care of the tail end without any need to discuss the additional evidence of the parachutes to the same effect.

The secondaries. Let us then turn to the secondaries. Most conspicuously, we have argued that what the Americans were looking for in the underwater operation was not the fabled bomb SN 78252, but the uranium 235 marshal's baton of a secondary.

The Star III submersible did find an object that appeared to fit the description that we have squeezed out of Sandia's report (doc. 107032), but on closer inspection it was apparently concluded that this was not the object being sought.

An AEC analysis quoted in the clippings below says that 85 percent of the uranium of three secondaries was recovered. Given the effort invested in recovering precisely the uranium 235 of the secondaries, this percentage may refer exclusively to the uranium 235 of the fissile cores of the secondaries, but we cannot be sure. Some of this amount was apparently found as intact cores, some in small fragments. We suspect that it was not always possible to identify these pieces of uranium 235 with any particular weapon and have to keep open the possibility that it could have come from all four weapons.

What is missing of the uranium 235 of the secondaries is in other words 15 percent by amount for three weapons plus 25 percent by amount for the four weapons taken together. But we cannot be sure that the Americans had been able to say with absolute confidence from which weapons each and every one of the recovered pieces had come. If this is correct, it means that they were acting on assumptions more than on undisputable certainty when they looked for a whole piece of uranium on the sea bottom, although they may have had other indications as well that made the underwater search look promising. Dr Walske does not seem to have been a firm believer in the necessity and usefulness of the underwater search.

This analysis of the hunt for the secondary fissile cores has many important implications. Let us mention only two of them. First, it goes squarely against any idea of a search for a bomb by telling us what the Americans were really searching for. Secondly, by giving an indication of how badly damaged the secondaries were, partly as a result of the explosions, it is evidence supporting the version of events that all four primaries were destroyed in conventional explosions, thereby dispersing – and this is most important for our understanding of the accident – not only all of the plutonium in the primaries, but also the uranium 235 of the composite primary pits.

We think that so many parts of the secondaries were recovered as to make it unlikely that SN 78252 should not have contributed to this collection of recovered items, which in the AEC account amounted to 94 percent by weight of three secondaries, whereas in the Air Force account we are told that 'Unnumbered parts of the bomb

secondaries were found widely scattered. These pieces accounted for less than three complete secondaries.' The poor individual who put these inconsistent sentences side by side in the short article 'Broken Arrow – Thule' could not suspect the unforgiving eyes that would be scrutinizing his prose forty years afterwards. Superficially the two sentences are saying more or less the same thing, but when taking into account the fact that the Air Force account calculates only the unnumbered parts, whereas the AEC is speaking of [all?] the recovered secondary components, question marks begin to abound.

Taken literally, the Air Force account means that we should add the numbered parts to the unnumbered, and what would we have then? 99 percent or what? As we know, one of the secondaries was found relatively intact and identified by number. Pieces of two other secondaries were also identified by number. Whether the apparent inconsistency between these two estimates carries some hidden meaning or is a result of carelessness we are not able to say. Besides, it is not even necessary to solve this small riddle. The evidence is on all counts overwhelming that all four secondaries broke up, some of them a great deal, one of them less so.

The paragraph of 'Broken Arrow – Thule' that we have been discussing here ends with one of those sentences that have been used by the media over the years as supporting evidence for the idea of a bomb on the sea bottom. It says: 'No parts of the fourth secondary have been identified'. Suffice it to say that this is a logical fallacy. When you have four secondaries at the outset and can identify three of them with the help of numbered parts and at the same time have a lot of unnumbered secondary parts that you cannot identify with any of the four weapons, then it does not follow that no parts of the fourth secondary have been found, nor that the fourth secondary remained intact. These 'anonymous' parts may not be attributable to a specific weapon, but that is not the same as saying that they have not been found. They might come from any of the four bombs.

Consider, for example, that you drop four identical glass vases over the frozen Bylot Sound from an airplane. Then you add a snow storm, some explosions, a giant fire and a hole in the ice. You then start a very careful search for the fragments of the vases and end up recovering 94 percent by weight of three vases. A stroke of luck lets you assemble a few of the found pieces into three somewhat larger parts, none of which fit together. You have thereby established the fact that three vases have been destroyed.

In front of you there is still a heap of glass debris. Despite your efforts, you do not succeed in joining any of these remaining pieces. Would you then start thinking that the fourth vase was still whole? Would you claim that it follows from your not being able to assemble a fourth fragment that a whole vase exists? You might, of course, but it would be a logical fallacy. Probably nobody would make such a claim if we exclude the unjust master who tells his servant that he has accounted for three vases only and accuses him of having stolen the fourth. Instead, if your preference were to think of whole vases, you would say that it could not be ruled out that a whole vase existed somewhere.

Statistically, however, it seems much more likely that some of the unidentified secondary pieces belonged to the fourth bomb. One need only consider the many thousands of pieces of debris reported on the sea bottom to recognize how unlikely it would be that the figure of 94 percent for three secondaries could be reached without the inclusion of parts from SN 78252, even though they admittedly could not be identified with it. This was, however, not unique to SN 78252. As we have said, lots of bits and pieces were defined as belonging to secondaries, but they could not be assigned to any special bomb and thus remained unidentified.

The primaries. We have also argued that all four primaries were completely destroyed by the explosions of considerable amounts of high explosives surrounding the primary pits. The only observed debris possibly of primaries we are aware of are the four pieces of scrap found on the sea bottom, but not recovered. In Thule we have no indications that any unexploded fragments of the high explosives of the primaries were found. This is yet another sign of the destructiveness of the explosions, lending further plausibility to the destruction not only of the primaries, but, in varying degrees, the destruction of the secondaries as well.

A lapidary but in some regards useful overview of recovered weapon parts is contained in the short article, 'Broken Arrow – Thule', by the Weapon Systems Division, Directorate of Nuclear Safety (Broken Arrow Thule 1968), already cited.

WEAPONS RECOVERY

The initial reconnaissance and early searches indicated that the 1- by 3-mile area south of the impact point was the prime area to be searched. While the total area searched was approximately 30 square miles, the search and recovery teams concentrated most of their efforts in the 1- by 3-mile area.

The four [redacted] bombs were contained in an MHU-20/C clip-in assembly in the aircraft. Bomb No. 690020 was in the lower right position (looking forward from the bomb bay), bomb No. 453171 in the upper right, bomb No. 815950 in the upper left, and bomb #78252 in the lower left. For easy reference, the four bombs were identified as No. 1, No. 2, No. 3, and No. 4, respectively.

Parts of the bombs were found scattered from the impact point southward for about 3 miles. The width of the scatter pattern was approximately 1 mile. Parachutes found in the burn or black area and within 1,000 feet of the impact point were heavily contaminated. Tritium reservoirs were located between 1,500 and 3,000 feet from the impact area. All reservoirs [redacted] had been deformed by the detonation of the high explosives in the bombs. The reservoir from bomb No. 4 was deformed in a different manner than the ones from the other three bombs. Parts of secondaries and bomb debris were widely scattered throughout the 1- by 3-mile area. Individual bomb status is given below. Figure 4 shows the location of the recovered bomb components.

- Bomb No. 1: Reservoir was found approximately 3,000 feet from the impact area. Parts of the secondary were found 1 mile and 2 miles south of the southern tip of the burn area.
- Bomb No. 2: Reservoir was located about 2,000 feet from the impact area. Part of the secondary [redacted] was found approximately 2¼ miles south of the impact point.
- Bomb No. 3: Reservoir was found approximately 1,500 feet from the southern edge of the burn area. [redacted]

[redacted]

• Bomb No. 4: Reservoir was found about 3,000 feet south of the impact area and 750 feet east of the reservoir from bomb No. 1.

Unnumbered parts of the bomb secondaries were found widely scattered. These pieces accounted for less than three complete secondaries. An analysis by the AEC of the recovered secondary components indicates recovery of 85% of the uranium and 94%, by weight, of three secondaries. No parts of the fourth secondary have been identified.

Other miscellaneous parts found were:

Two 64-foot parachutes
Two 16¾-foot parachutes
One unidentified parachute
One tail closing plate
Two valve assemblies
One piece of case section, 2¾ feet by 4¾ inches
One part of a low voltage power supply
One front plate of a parachute deploying device
One piece of coupling ring
Four bomb lugs
One piece of aluminum plate from fuze section (back of honeycomb)

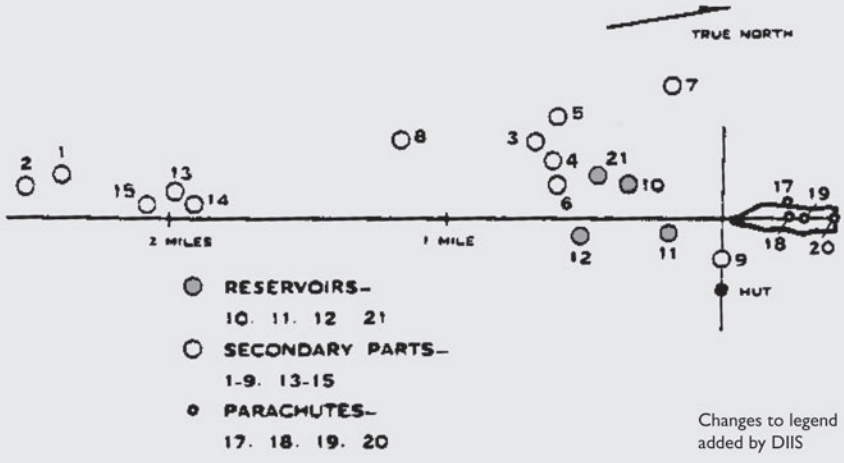
Two irregular pieces of tuballoy—pencil size

All recovered bomb components were moved from the crash area to Thule Air Base for inspection, identification, and packaging by AEC/PANTEX personnel prior to shipment to AEC facilities in the CONUS.

The same document contains a sketch of where the weapon parts were found (Broken Arrow Thule 1968). The parachutes were found close to the impact point with the crushed ice. The reservoirs (tritium bottles/DT bottles) that broke off from the tail ends of all four weapons followed the direction of the crashing aircraft towards the south, while the heaviest pieces, parts of the secondaries, slid like curling stones with an initial speed of close to 300 m/sec as far as 2½ miles from the impact point. The secondary part shown as no. 8 not so far from the 1

mile mark is probably one of the uranium fissile cores. This section was said to weigh 20 pounds (9 kg).

Thule debris field showing locations of major weapon components



And now to the other main part of the argument, the plutonium question, or the plutonium balance sheet. This topic is normally treated from the point of view of the plutonium contamination of the environment, but in the context of this report, with its limited objectives, it is dealt with mainly in two interrelated directions. The first of them is the question we have just been dealing with: can the balance sheet tell us something about the fate of the primaries?

Estimates of released plutonium and plutonium contents in the weapons

The question of how much plutonium there was in the weapons has become a hornets' nest for all the parties involved.

For the American authorities, this is because, for understandable reasons, they wanted to keep the quantity secret as part of the set of 'secret restricted data' about nuclear weapons. After giving the issue some thought, they finally declared that 6 kg were 'involved in the accident'. This amount, we originally thought, did not necessarily reflect

the full plutonium contents of the weapons, but it could perhaps rather be understood as an estimate of the original level of plutonium contamination in the Thule area. We must admit that at the outset we were skeptical about the precision of this amount as an expression of the total content of plutonium in the weapons, but gradually we have become convinced that the figure of 6 kg is a close approximation or a 'rounded-off value', as Dr Walske put it in his energetic defence of giving this number to the Danes. This is at the low end of the real figure, which is probably closer to 7.5 kg.

However, Walske's exquisite piece of bureaucratic compromise and diplomatic craftsmanship should not make us believe that the Holy Grail had ceased to exist. Technical specifications concerning the contents of the four bombs on the B-52 were still considered 'secret restricted data'. This was amply illustrated in a meeting at Washington in late August 1988 between representatives of the Danish National Board of Health and U.S. officials. The meeting heard Danish questions relating to the amount and character of dispersed radioactive material, especially the contents of the bombs and the amount of plutonium in aircraft and bomb debris shipped back to the U.S. in 1968.

A somewhat elated State Department official, in a florid display of diplomatic omnipotence accompanied by melodramatic gestures, told the Danish delegation about the chances of getting this information. They would be roughly the same, he said, as that all oxygen molecules in the room would concentrate in a corner under the ceiling. Still not fully exhausted, the official continued to declare that the State Department did not consider itself to be under any obligation to answer the questions of the Danish National Board of Health since in the American understanding this did not represent an official approach by the Danish government through channels.

This uncompromising attitude was, however, softened up seven years later in a few sentences in the 'Final Response to Danish Questions'. Had these sentences been part of a newly discovered manuscript fragment of the Holy Scripture, we suspect that a solid body of exegetic literature would have sprung up around them. Representing, after all, a text not of God but of bureaucratic machinery, these sentences have apparently not been noticed as much as they deserve.

Here is what the 'Final Response' says. 'At the time of the accident, the US furnished the Danish scientists with a very reasonable estimate – 6 kilograms – of the actual amount of plutonium involved in the four weapons' (answer 2) and 'the Danish scientists had been informed as early as April 1968 that the four nuclear weapons involved in the

Thule accident contained a total of about 6 kg of plutonium' (answer 9). Once you are aware of these new formulations, it is quite clear that they are very different from the traditional formula, which cites 'The fact that approximately 6 kg of plutonium were involved in the Greenland accident' (answer 8) ('Final Response' 1995).

The reader will note that the drafters have been revelling in moving the word 'involved' around in these sentences as if to discover how many substitutions and transformations this small innocent word could undergo before completely losing its substance. To cover this daring game with words, the different versions are carefully placed in diverse answers at a safe distance from each other.

The reason for the obsessive use of the word 'involved' in these sentences is obvious. It is a small face-saving device meant to conceal the for a bureaucrat embarrassing fact that he has changed the canonized 27 years old formula. We should, however, not deplore this bureaucratic needlework since the end result is highly satisfying. Probably for the first time in the history of the United States, an official document has come as close as one can expect to disclosing the content of plutonium in actual weapons. The relevant passages deserve repeating: 'Danish scientists had been informed as early as April 1968 that the four nuclear weapons involved in the Thule accident contained a total of about 6 kg of plutonium' and 'At the time of the accident, the US furnished the Danish scientists with a very reasonable estimate – 6 kilograms – of the actual amount of plutonium involved in the four weapons.'

Unquestionably, these endeavours must have been approved by the Director of Classification of the Department of Energy and deserve their rightful place on DOE's website, along with its long lists of small things you can say about nuclear weapons (DOE 1996).

One other detail stands out as well, namely the strong emphasis on the fact that this figure has been used all along since 1968. There is some truth in this, as our reference to Asker Aarkrog's diary shows, and it is of course equally true that the sentence of choice: 'The fact that approximately 6 kg of plutonium were involved in the Greenland accident' was shared with the Danish authorities and scientists in 1968. The use of '1968' examples in these sentences represents, we think, another attempt to create the impression that this is all old hat and has been repeatedly declared ever since the accident. The probably unintended side effect of this strained argument is to imply that somehow the Danes are a bit slow.

To conclude, this was a most welcome breakthrough in the American declarations about the amount of plutonium released in the Thule accident, and at the same time it appears to provide supporting evidence of our interpretation of what Dr Walske tried to accomplish back in April 1968.

In the end, as much as all the above may be of interest for aficionados of the maze of diplomatic language, in practical terms it appears to be a question of one or two kilograms of plutonium more or less. As to the diplomatic language aspect, Osvald Helmuth or John Wayne probably could not have cared less.

Ironically, the ingenious, broadminded compromise of Dr Walske has not had the reassuring effect that was intended. In the public mind of Danes and Greenlanders, this problem continued to raise questions because some of the common reference works on the subject to this day operate with 6 kg of plutonium per weapon as the minimum. In four weapons this would mean 24 kg.

People would then start asking questions. 'If the authorities say that 6 kg of plutonium were involved and that all four weapons exploded in a conventional explosion, where, then, have the 18 kg gone?' This has led to a perception that there might be inconsistencies between the official figures and the real figures and that either there might be more contamination than reported by the authorities, or conversely that some of the weapons were not destroyed in the accident and therefore might still be present at the bottom of the sea.

Thus, despite many official explanations over the years, the perception is still alive that some undisclosed risks might exist, either in the form of a higher degree of contamination than reported, or in the form of still existing bombs.

We are not pretending that we know exactly how many kilos of plutonium there were in the bombs. The issue in this report is not absolute precision, but whether the amount is closer to reality than to fantasy. As long as some people were operating with the perceived gap between 6 kg and 24 kg, the credibility gap between government explanations and popular beliefs was not going to disappear easily.

We believe that we have discovered an amount close to reality, as well as established some common ground around an epicenter of about 7.5 kg, that is, 7.5 kg in the weapons and 7.5 kg released in the explosions. Approximations, of course, but close,

which means that we can again begin to talk reality and reestablish some of the lost confidence.

It is therefore with a certain satisfaction that we are able in this report to present a plutonium estimate that might alleviate some of the worries and suspicions that have been a factor in the history of the Thule accident for more than forty years. Yet, in order to proceed along the route of confidence towards better monitoring and improved conditions for research, we need the release of more data, for instance, concerning the final results of the measurements of the filtrate at Savannah River, of the debris in the igloo at Thule, of aircraft debris in general, and of the recovered weapons parts at Rocky Flats and elsewhere (cf. for instance docs. 104812 and 104813). There is no missing bomb, but there are missing documents. Fortunately, DOE has stated that public input is welcome regarding how the Department may release information of legitimate interest to the public while maintaining control of information important to national security (DOE 1996).

The first of the Eureka! experiences in this part of our research was the result of a simple consultation of the reference work *World Inventory of Plutonium and Highly Enriched Uranium 1992*, giving 2 kg in early weapons (Albright et al. 2003). Until now, many people seem to have operated with a figure of 6 kg plutonium per weapon, and hardly anybody appears to have noticed that DOE declassified 4 kg in 1994 as the theoretical minimum for modern weapons, which presumably means weapons of the 1990s. This information has been floating around freely for over a decade, at least. More than anything else, it shows how compartmentalized information has become.

After that, other bits and pieces pointing in the same direction started to surface. They are presented in the first of two tables in the appendices. The second table gives estimates and measurements of released plutonium.

The second Eureka! came later. In the final stage of our investigation, one of those documents that historians like to call 'jewels in the crown' suddenly began to speak. The jewel in the crown in this respect was two lines with three figures in the hand-written minutes of a meeting in Washington on 5 February 1968 (doc. 107152). On the basis of these two lines, we arrived at roughly 7.5 kg of plutonium for the four weapons.

After several decades of discussion, we have established a plausible correspondence between the amount of plutonium 239 that was dispersed into the environment or

impinged into the weapon and aircraft debris by the conventional explosions of the primaries, and the amount of plutonium 239 actually contained in the weapons to begin with.

This is a breakthrough in the investigation of the accident, although achieving it is certainly not rocket science. The importance lies in the fact that the agreement between the figures, with its basis in independent sources as well as a tiny piece of uncensored official information, helps to remove grounds for doubting the official explanations as to what actually happened, thus creating a basis from which to start rebuilding confidence. We cannot, however, provide a final material balance. That is a task for the authorities and the natural sciences.

6. Summary of the evidence

The attempt at a historical reconstruction of the events in Thule in 1968 has been undertaken with the aim of testing various explanations of the fate of the four thermonuclear weapons involved in the accident.

For a start, it is important to notice that we are not fully informed about the weapon items that were recovered at Thule. As far as we know, none of the more comprehensive reviews of recovered weapons parts has been released. The short, excised survey in the DoD FOIA reading room is lapidary, to say the least, but still useful. Many portions have been deleted in the released documents. The excisions apparently almost uniformly have to do with weapons design, weapons data, communications and other classified issues.

One of the most sensitive issues in the area of restricted data was the amount of plutonium 239 in the pit of the primary stages of the four weapons. Many other aspects of nuclear weapons design were also considered restricted data. This is still the case, and most people can probably see the justification for keeping nuclear secrets closely guarded. Yet, as we have shown, back in 1968 the U.S. Government did in fact declassify– in a thinly veiled form – a figure for the total plutonium content of the weapons that was nearly correct.

Once this figure became public, hardly anybody believed it. Apparently, the lesson to be learnt from this is that it is safe to make your secrets known to the public as long as you release some relatively unimportant sanitized documents as well. The result of this intricate mix of openness and secrecy can lead to such levels of confusion that nobody will take your word, especially when you are actually speaking the truth.

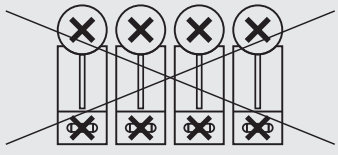
The irony of protecting secrecy in a democratic state is that secrecy tends to undermine the citizens' confidence in the very state that exists to protect them and that needs secrecy to do so. We are deluding ourselves if we think that the subtle balance between transparency and secrecy can be clearly defined and that the wisdom needed to administer this balance genuinely in the public interest is always available.

What happened to the bombs?

That question was the point of departure for this report. We too have experienced disappointments in the search for the bombs. At the outset of our research, we established two 'theories' to frame our examination of the documents. They were pure constructs meant as simple research tools to help us analyse the events. After some drafting we had to give up this approach, as it turned out that the tools were not useful, but instead had become a burden leading to a good deal of needless repetition.

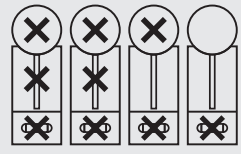
However, in order that this effort should not be entirely wasted, we will allow the reader a short glimpse of our misguided first steps in the process. We called these tools the 4 bomb theory and the 1½ bomb theory in order not to be left behind by the BBC, and we illustrated them with the icons below that show the three main parts of the weapons: the primary, the secondary and the tail end. The small crosses signify that the weapons have been 'accounted for', that is, either destroyed or recovered.

4 bomb theory



The 4 bomb theory simply said that all primaries were destroyed by the conventional high explosives and that all the tail sections broke off on impact, including the tritium bottles. This means that there were no bombs left.

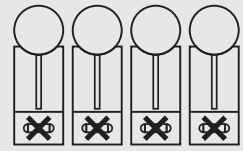
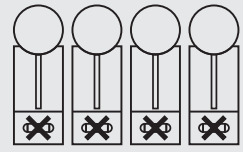
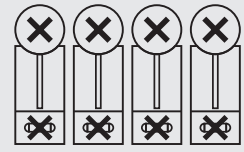
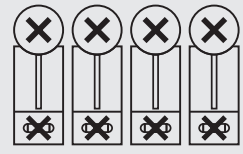
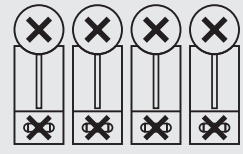
1½ bomb theory

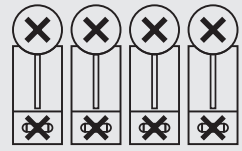
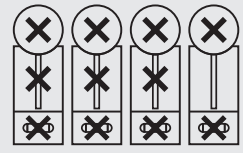
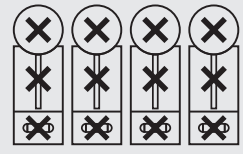
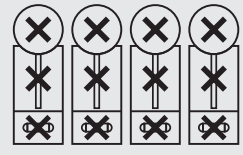


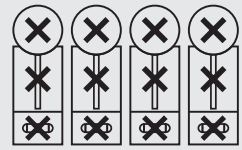
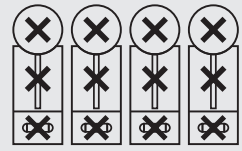
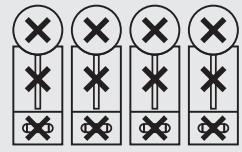
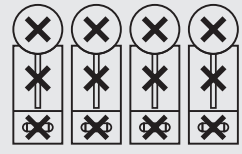
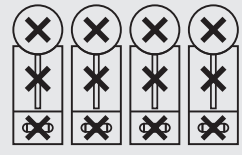
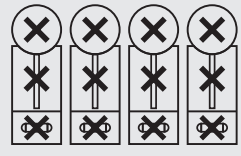
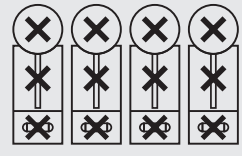
A 'realistic' 1½ bomb theory acknowledged the obvious: that all the tail ends of the weapons, including the absolutely essential tritium bottles (reservoirs), broke off. It pretended to know what happened to 2½ bombs and was skeptical and wanted to know about '1½ bombs', or to be precise, one primary and two secondaries.

As we said, this tool was not useful. It generated a lot of repetitive argument and provided no new insights. What we have saved is the icon approach, which we will use in the following summary of the evidence and arguments.

The fate of the bombs: summary of evidence, arguments and explanations

Argument and explanation	*Parts destroyed or recovered*
Four reservoirs were recovered. Each of them could be matched with a bomb. *Proves* that the four weapons had become nonoperational and destroyed as weapons. *Proves* that no complete, operational bomb had survived the crash. The location of the reservoirs on the ice near the impact point and close to each other indicates that they broke off simultaneously.	
Four parapacks were recovered. *Proves* that no complete bomb had survived the crash. *Supports* the above reservoirs argument.	
Crash velocity, enormous fire, quality of high explosives (HE). *Indication* of the plausibility that all four primaries in Thule would go off in conventional HE explosions. In the years following the accidents in Palomares and Thule, the HE material was modified to avoid explosion on impact. IHE was introduced in 1979 (Chapter 4).	
Comparison with Palomares accident, bombs 2 and 3. *Indication* of the plausibility that all four primaries in Thule would go off in conventional HE explosions.	
The plutonium balance sheet. *Indicates* that the plutonium in all four primaries was dispersed in the conventional explosions.	

Argument and explanation	*Parts destroyed or recovered*
Only few fragments found of the primaries. *Indicates* that all four primaries were destroyed by HE explosions and fire.	
Many fragments of secondaries recovered. *Proves* that at least three secondaries were destroyed. *Indicates* that the fourth secondary was destroyed, too. Unnumbered parts of the bomb secondaries were found widely scattered. These pieces accounted for less than three complete secondaries. An analysis by the AEC of the recovered secondary components shows a recovery rate of 94 percent, by weight, of three secondaries. Three secondaries seems an incredibly high recovery rate if we don't assume that some of the widely scattered unnumbered parts belonged to the fourth secondary. The weight argument definitely takes three secondaries away and most likely also the fourth.	
The hunt for uranium 235 with SPA-3 on the ice *Proves* that a focused search for the fissile cores of the secondaries was performed, including one that was believed to have fallen to the bottom. *Supports* the argument that the secondaries had disintegrated, except for one that was recovered relatively intact.	
Definition of the marshal's baton as the missing object, which is not a bomb and not a secondary, but the small fissile core of a secondary. *Proves* that the search was not for a secondary. From the early and very precise definition of the 'missing' weapon component, it can be deduced that the fourth secondary was not considered searchable. *Proves* that the fate of the three other batons was known. This is supported by the fact that 85 percent of the uranium of three secondaries was recovered. The Disaster Control Team and the experts back in America had sufficient and quite extensive knowledge about the fate of three secondaries. They must have reached the conclusion that the fourth secondary had disintegrated as well.	

Argument and explanation	*Parts destroyed or recovered*
The vase example. *Disproves* as a logical fallacy the idea that, if none of the many unnumbered pieces from secondaries had been identified as belonging to a specific weapon, then it follows that this secondary would still exist as a whole component which has not been found (Chapter 5).	
The discussion and the decision-making regarding an underwater operation. *Proves* that the dives were not a very high-priority operation. No really important part was missing in the eyes of the top decision-makers. Serves as further confirmation that the search was not for a secondary.	
The very limited recovery capability of Star III. *Proves* that the search was not for a secondary, but for something much smaller.	
Comparison with the underwater operation in Palomares. *Proves* how much more important the operations in Palomares were.	
16 hours of underwater video with a pronounced interest in objects the size of a marshal's baton. *Supports* the claim that the underwater operation was a search for the marshal's baton, not for a secondary.	
The decision to stop the dives. *Supports* the argument that this was a comparatively low priority operation. The missing baton was, after all, not that important. *Supports* the argument that the search was not for a secondary.	
The fact that the hunt for the marshal's baton was unsuccessful and that no other parts of a secondary were observed on the sea bottom. *Supports* the argument that the search was not for a secondary.	

This concludes the summary of the evidence concerning the fate of the four nuclear weapons.

The argument about a 'missing bomb' – which, correctly put on its own premises, is actually a 'missing secondary' – has been put forward at regular intervals since 1987. In its later versions, it stands on two pillars: 1) that none of the unnumbered secondary parts could be matched with bomb SN 78252; and 2) that uncertainty, rumours and a certain amount of secretiveness surrounded the Star III diving operations.

Unambiguous evidence replaces the second part of the argument. We know that the Americans were looking for the marshal's baton. Without the support of the second pillar, the first pillar crumbles under the weight of its own logical fallacy and the evidence presented in this summary.

7. Conclusions

Some of the sources for a historical reconstruction of the events surrounding the recovery of the nuclear weapons after the Thule accident have been excised or made exempt from declassification.

In some respects, the conclusions presented here can not supply irrefutable evidence of past events. This is not unusual for historians, who must be content to establish the likely and the plausible.

With this in mind, we have concluded the following:

About the sources

The foreign minister's specific question to DIIS was whether the 348 documents obtained by the BBC journalist Gordon Corera in 2001 contained decisive new information as compared with the 317 documents declassified by the Department of Energy (DOE) from 1986 onwards and released by DOE in September 1994.

No new document-based assertions about the bombs were made in 2008, and the documentary evidence was much the same as that released by DOE in 1994 and used in 2000 in an article in *Jyllands-Posten*. BBC's second assertion about withheld information concerning the true meaning of the bottom survey could be called 'new news' as far as the extensive media coverage is concerned, but it was based on an old, well-known document that was declassified in February 1991 and formed part of the 317 collection of documents.

Our report is primarily based on the 348 collection, that is, the same U.S. documents that in many cases have been declassified for nearly two decades, but additionally it takes in a few documents from Danish and other archives. What is new in this report, in other words, is not so much the sources as the analysis and interpretation of mostly familiar documents.

About the weapons

We have shown beyond any reasonable doubt that all four weapons broke up in the crash and became nonoperational: they did not exist as weapons after the crash.

This is an indisputable fact already because the deuterium/tritium reservoirs in the tail sections of the four weapons broke off on impact and were recovered close to the impact point.

We can provide a clear answer: there is no bomb, there was no bomb, and the Americans were not looking for a bomb.

We have found strong indications that all four primaries were destroyed in conventional explosions on impact. The primary is the first stage of the bomb.

The plutonium in the primaries of all four weapons was dispersed in particulate form in the explosions and the ensuing fire.

This is in all important respects consistent with what happened in the low-order explosions of the high explosives in two of the bombs in the Palomares accident two years earlier, and equally consistent with the consequences of this for the secondaries and for the character of the dispersed active particles at Palomares.

We have argued that all four secondaries were destroyed as well, but not in all cases with the same devastating consequences for these sections as for the primaries.

About the plutonium

Thus far there has been some public disbelief that all four primaries actually exploded. This disbelief was caused by the idea of a discrepancy between the 24 kg of plutonium thought to be needed to reach criticality in the four primaries taken together, and the approximately 6 kg that the authorities claimed to have been involved in the accident.

Skeptics among the public would say that either all four primaries did not explode (leaving the possibility of a 'missing bomb') or the supposed 24 kg had not been accounted for properly (meaning that the contamination was worse than admitted).

We believe that, after several decades of discussion, we have established that the amount of plutonium 239 dispersed as very small particles in the conventional explosions of the weapons roughly corresponds to the amount of plutonium 239 actually contained in the weapons to begin with.

This is a breakthrough in the investigation of the accident, although achieving it is certainly not rocket science. Its importance lies in the fact that the agreement between the figures helps to remove grounds for doubting the official explanations as to what happened and may mark a new beginning in rebuilding confidence on this account. We cannot, however, provide a final material balance. That is a task for the authorities and the natural sciences.

This finding, simple as it is, was one of the Eureka! moments in our investigation. And, as sometimes happens, the solution was lying right on the doorstep. After weeks of consulting the literature and the experts in various fields without result, we finally turned to the disarmament literature.

As a reference value, this gave a figure of roughly 2 kg of plutonium 239 per weapon. After that, several other pieces of information pointing in the same direction began to surface.

The jewel in the crown in this respect was two lines with three figures in the hand-written minutes of a meeting in Washington held on 5 February 1968. On the basis of these two lines, we arrived at a figure of roughly 7.5 kg plutonium for the four weapons.

In the 1950s and 1960s, the primary pits consisted of large amounts of uranium 235 and relatively small amounts of plutonium 239. The standard reference value for plutonium 239 in the weapons of that period is about 2 kg. In later weapons, when the amount of uranium in the pit mix was reduced, the minimum amount of plutonium grew to perhaps 4 kg, a figure for modern weapons that was declassified by the U.S. authorities in 1994.

About the underwater search and the 'missing component'

No nuclear weapons have been left on the bottom of the sea in Thule, nor was any secondary left in the sea. The arguments are listed in the summary of evidence, among them the fact that the weight of nearly three secondaries (94%) was recovered and shipped to the U.S. Many of the secondary pieces were small and unnumbered and were found widely scattered on the ice.

Reaching a figure of 94% by weight for three secondaries seems improbable under the circumstances if pieces from only three weapons had been collected. It is

much more likely that this figure was reached by recovering pieces from all four secondaries.

We believe that by April 1968 the U.S. authorities already had a very good idea of what had happened to all four secondaries. If not, it would be incomprehensible how they could ask Sandia Corporation to establish trajectories in the water of Bylot Sound for one special, extremely well-defined weapon component – only one, and certainly from a secondary. This is the second jewel in the crown of the investigation.

We believe that what the Americans were looking for was the marshal's baton, the fissile core of a secondary, often referred to as the spark plug. The object was cylinder-shaped with rounded ends. Its drag coefficient was calculated by Sandia Corporation to be 0.6 head on and 1.0 side on. It could have been a massive rod, but it is far more likely that it was a pipe with sealed ends. The sources provide ample evidence that such pieces were recovered on the ice in February and March 1968, and that the hunt for the remaining pieces continued to the end of the operation in August 1968.

There is a solid body of evidence that the marshal's baton contained uranium 235. We believe that the documents refer to the marshal's baton as the 'secondary pit' and the 'oralloy pit', although no experts seem to remember or know this terminology. If we suppose that the marshal's baton contained 8 kg of uranium 235, it would have had a volume of roughly four decilitres. A cylinder with such a volume could, for instance, be 50 centimetres long with a diameter of 3.3 centimetres, or somewhat thicker if it were a pipe, for instance, 5.4 centimetres with a wall thickness of 1.1 cm.

This is a rather small object to find on the sea bottom, especially when we remember that it could have broken to pieces and might be located among thousands of other pieces of debris. Yet, it is bigger than a spark plug in a car. We have chosen to call it the marshal's baton instead. The size fits this description better.

That an object of this size was indeed what the American Star III submersible was looking for is demonstrated in the video footage from the dives where the claw can be seen recovering an object fitting this description. On closer inspection, the object apparently turned out not to be the sought-after prize.

Finally, we must not forget that the decision-makers and search teams could not be sure that the sought-after component had survived the crash. One would assume

that they kept an open mind for the possibility that it had been blown to pieces or completely destroyed in some other fashion.

The BBC has exaggerated the confidentiality of the underwater operations. These operations were carried out under an agreement reached in a number of Danish-U.S. meetings. H.H. Koch, the Chairman of the Danish Atomic Energy Commission, understood perfectly well that the bottom survey was not a major operation.

We can return to our previous answer in a more elaborate form: there is no bomb, there was no bomb, and the Americans were not looking for a bomb. They were looking for the marshal's baton. Nor were there any whole pieces of any of the primary stages, nor any whole ones of any secondary stage, nor any tail section left behind.

This may be the place to quietly observe that the Danish foreign minister's 1987 statement about the dives, reproduced in the introduction, was absolutely correct.

To repeat, the Americans were not looking for a bomb but for a weapons component, almost certainly a uranium 235 fissile core from the secondary stage of a weapon. They were probably not at all sure if it had actually fallen to the bottom and in what state, nor whether it still existed. Crumbling of uranium metal in water has been observed in many studies. If there were something to be found, they did not find it in the last days of August 1968.

A comparison with the search for the missing bomb in Palomares two years earlier deals a final heavy blow to the idea of a nuclear weapon on the bottom of the sea in Bylot Sound. It is obvious that the sea bottom search in Thule had an infinitely lower priority than the successful search in Palomares.

We derive this conclusion from an analysis of the discussions in Washington, as well as from the very different dimensions of the respective underwater operations. The extensive side track sonar scans in Bylot Sound in 2003 performed by the Geological Survey of Denmark and Greenland showed no signs of debris from the crash, only an old iron frame. The jewels were in the archives, not in the sea.

Annex

DIIS REPORT

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Walske-Koch 15/4 1968. Letter from Carl Walske to Hans H. Koch, [with 9 enclosures (1 missing) (radiological survey data) [these survey data are found in Crested Ice SAC 1969 as well]. [The missing enclosure is Sandia Corporation's report of 12 February 1968 on the atmospheric dispersal of contamination from the Thule crash, which is available in the 317 and 348 collections as doc. 106918. Incidentally, Sandia's report had already been delivered once, by hand, in Copenhagen 13 February 1968 (doc. 106917)]. Copenhagen: Rigsarkivet, 1129 Atomenergikommissionen (AEK), 1961-1971, journalsager 1966-1971, pk. 271

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Appendices

Basic crash data: The plane, the bombs, the explosions, the site, the ice, the sea bottom, the submersible

Appendix 1

The crash

Excerpt from Wright H. Langham: Technical and Laboratory Support, p. 37, in Project Crested Ice. A Joint Danish-American Report on the Crash Near Thule Air Base on 21 January 1968 of a B-52 Bomber Carrying Nuclear Weapons, Danish Atomic Energy Commission, Research Establishment Risö (Risö Report No. 213), February, 1970, pp. 36-41.

Downloaded from
http://www.risoe.dtu.dk/knowledge_base/publications/reports/ris-r-213.aspx?sc_lang=en

The speed of the plane on impact was in excess of 500 knots. Its gross weight was about 410,000 pounds, including about 225,000 pounds of JP--1 fuel. The shallow impact angle and mass and speed of the aircraft resulted in a great forward vector of momentum. When the high-explosive components of all four weapons detonated, the contamination was blown out in all directions, impinged into the materials of the weapons and the aircraft, and blown into the splashing, burning fuel. The fuel and much of the debris from the aircraft were catapulted forward along the surface of the ice. When the burning fuel fell back to the surface, the fire was soon extinguished, leaving the blackened re-frozen crust on top of the snow pack. The ice was completely shattered and disoriented at the impact point and sustained circular cracking out to a distance of about 100 yards in all directions.
The peculiar markings on the ice showed the drag and destruction of the left wing, from which the crash attitude of the plane was deduced. From momentum considerations and the pattern on the snow pack, one would expect to find a large fraction of the surface contamination confined to the blackened crust, where it was fixed by refreezing of the melted surface. This was indeed found to be the case.

The remainder of the contamination was dispersed in the smoke plume, impinged on the debris of the bombs and the aircraft, and blown into the ice at the site of impact.

The ice

Excerpt from Børge Fristrup: Ice Investigations, p. 86, in Project Crested Ice. A Joint Danish-American Report on the Crash Near Thule Air Base on 21 January 1968 of a B-52 Bomber Carrying Nuclear Weapons, Danish Atomic Energy Commission, Research Establishment Risö (Risö Report No. 213), February, 1970, pp. 84-86.

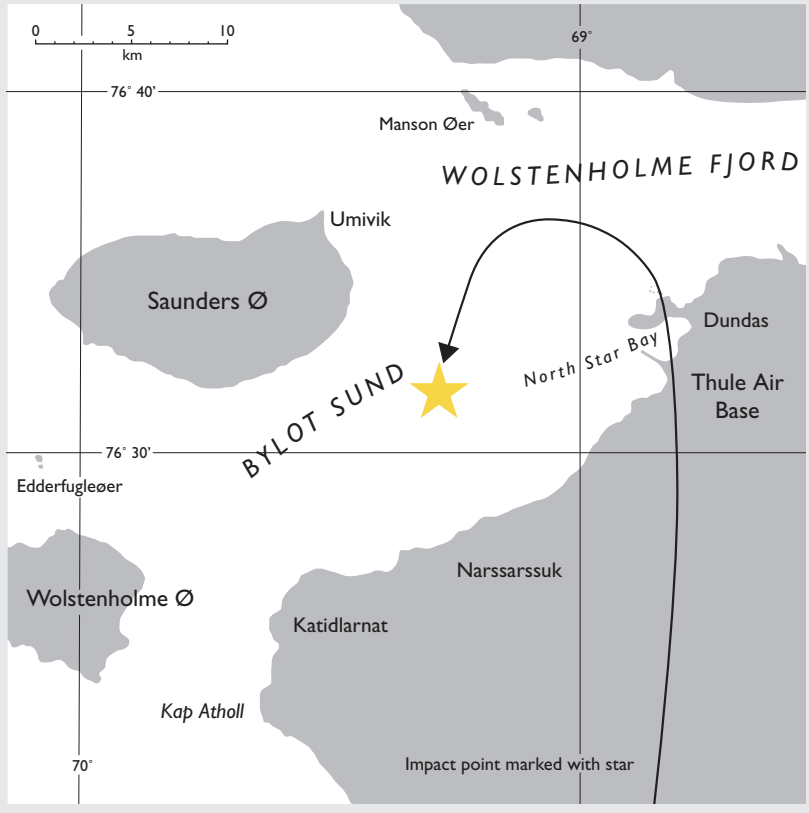
Downloaded from
http://www.risoe.dtu.dk/knowledge_base/publications/reports/ris-r-213.aspx?sc_lang=en

On the basis of these observations and the knowledge acquired previously by this author, one obtains the following reconstruction of these events. When the airplane crashed, the ice was crushed and for a short time a lane was formed, filled with floes and bits of ice. One-fifth or one-third of this lane may have been open water. It is difficult to obtain an accurate estimate of the size of the lane, since all the irregularities and floes were covered by drift snow after the accident, but a diameter of about 50 meters (approximately 165 feet) seems likely. It was evident that parts of the B-52 could have sunk to the bottom through this lane.

The 'black spot' showed where the burning fuel had streamed from the airplane when it hit the ice. The heat from the fire had no doubt been considerable, but it is also well known that heat does not penetrate deeply into snow. Within this area, no traces were found of large pieces of debris hammered or melted down through the ice, and with an ice depth of 70 cm (27 inches), small objects could not have penetrated the ice either way.

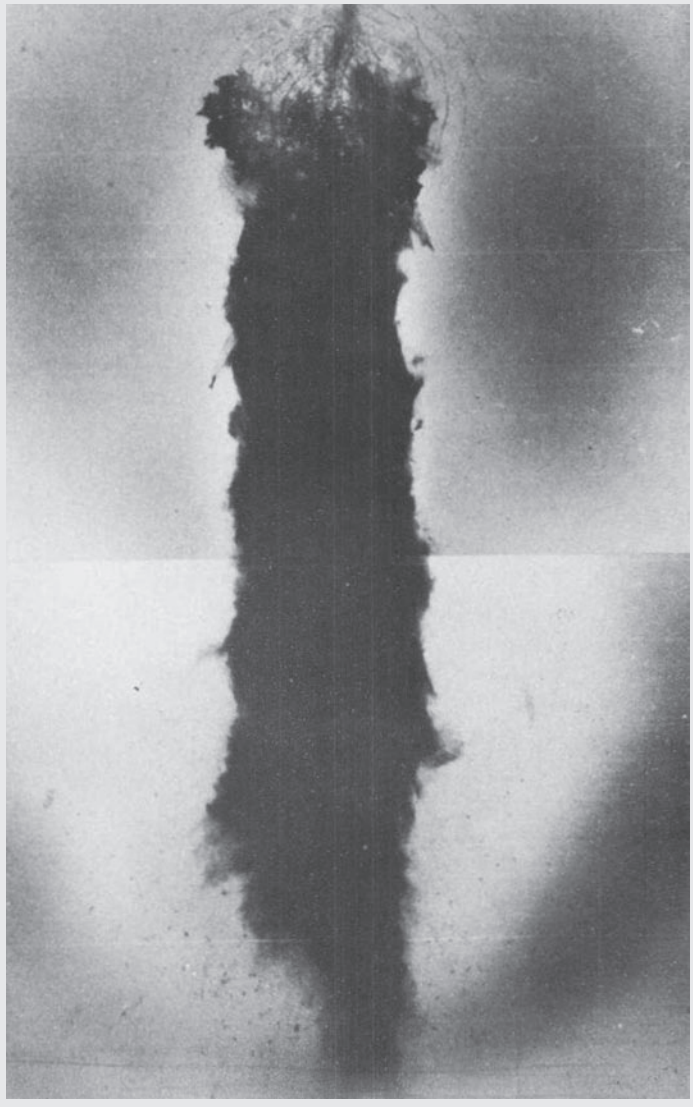
A number of corings in the crushed ice area showed a layer of impurities large enough to be detected with the naked eye. Several of them looked like drops of oil. The measurements showed that this horizon, fairly close to the underside of the ice, was strongly contaminated. The layer of impurities corresponded to the underside of the ice at the moment of the crash. The impurities stemmed from the accident and had been swimming in the water immediately under the ice cover and were thereafter incorporated into the ice as it grew downwards. The records show that the ice grew at a rate of approximately ½ cm (0.2 inches) per day at the beginning of February.

The site



Crash path prior to impact on ice

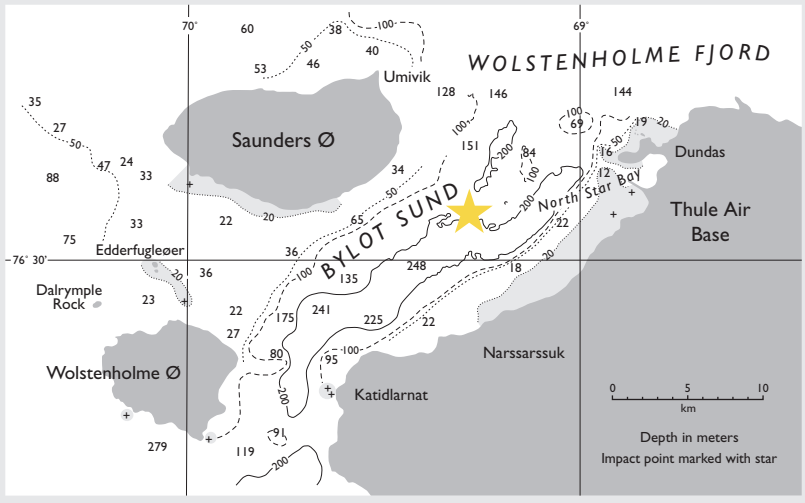
Source: Jørn Bo Jensen: Akustisk kortlægning af havbundssedimenterne i Bylot Sund, Thule 2003 [Acoustic Mapping of Sea Bottom Sediments in Bylot Sound, Thule 2003] (Danmarks og Grønlands Geologiske Undersøgelse Rapport 2003 / 1 0 3 [Geological Survey of Denmark and Greenland, Copenhagen]).



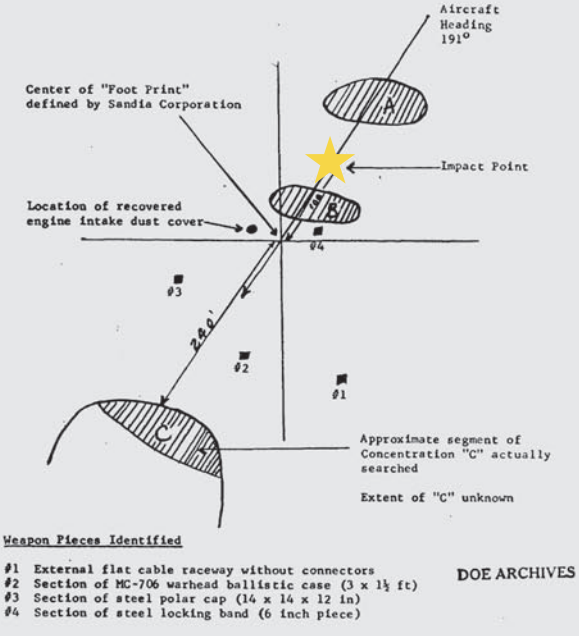
Aerial photograph of the crash site

A blackened area of ice approximately 500 x 2100 feet and, according to initial helicopter research, conducted in the polar night with no large pieces of aircraft debris in sight except the engines.

The Sea Bottom



Bathymetric map of Bylot Sound



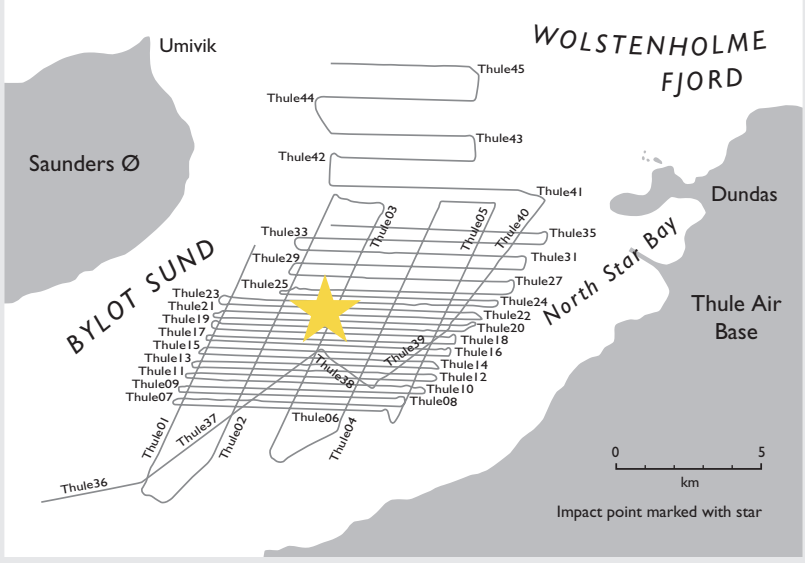
Bylot Sound Thule. Eleven dives in the impact area with the submersible Star III in August 1968, doc. 107059.

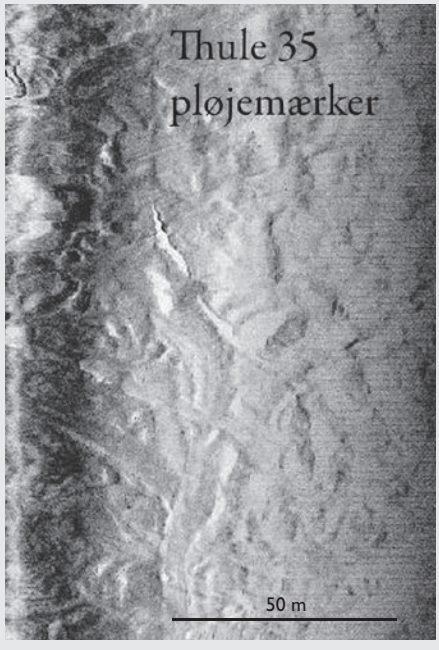
GEUS bottom survey 2003

Maps of the combined side scan and chirp survey conducted by GEUS in 2003. The survey encompassed a much larger area than the US surveys in 1968.

The distance between the East-West tracks is 200 meters, which provides almost complete area coverage of the bottom.

Source: Jørn Bo Jensen: Akustisk kortlægning af havbundssedimenterne i Bylot Sund, Thule 2003 [Acoustic Mapping of Sea Bottom Sediments in Bylot Sound, Thule 2003] (Danmarks og Grønlands Geologiske Undersøgelse Rapport 2003 / 1 0 3 [Geological Survey of Denmark and Greenland, Copenhagen]).





Iceberg scour marks revealed by the side scan. Such ploughing marks are characteristic of one of the bottom types in Bylot Sound. They indicate that icebergs often scour the bottom and disturb sedimentation. Jørn Bo Jensen, op. cit., pp. 23, 27.

Explosion types

Low Order Explosion
Low explosives change into gases by burning or combustion. These are characterized by deflagration (burning rapidly without generating a high pressure wave) and a lower reaction rate than high explosives. The overall effect ranges from rapid combustion to a low-order detonation (generally less than 2,000 meters per second). Since they burn through deflagration rather than a detonation wave, they are usually a mixture, and are initiated by heat and require confinement to create an explosion. Gun powder (black powder) is the only common example.

Detonation
Also called an initiation sequence or a firing train, this is the sequence of events which cascade from relatively low levels of energy to cause a chain reaction to initiate the final explosive material or main charge. They can be either low- or high-explosive trains. They involve a chemical reaction that moves through an explosive material at a velocity greater than the speed of sound in the material. A detonation is a chemical reaction given by an explosive substance in which a shock wave is formed. High temperature and pressure gradients are generated in the wave front, so that the chemical reaction is initiated instantaneously. Detonation velocities lie in the approximate range of 1,400 to 9,000 m/s or 5,000 to 30,000 ft/s.

High Order Explosion
High explosives are capable of detonating and are used in military ordnance, blasting and mining, etc. These have a very high rate of reaction, high pressure development, and the presence of a detonation wave that moves faster than the speed of sound (Mach 1, or 331.46 meters per second, at sea level). 'High Order Explosion' also often means that, because the HE carries all the oxident required for the complete combustion of the explosive material in a charge, there is, in fact, a complete oxidation or a High Order Explosion of all of the explosive material. Without confinement, they are compounds which are initiated by shock or heat and have high brisance (the shattering effect of an explosion). Examples include primary explosives such as nitroglycerin that can detonate with little stimulus, and secondary explosives such as dynamite (trinitrotoluene, TNT) that require a strong shock (from a detonator such as a blasting cap).

The pit in the primary

154. A description of the sealed pit weapon and further explanation of why it represented a significant advancement in weapons development is in order. The sealed pit atomic device normally associated with the so called "new family" of weapons consists of a metal sphere and explosive lens charges similar to the older type bomb. The term "pit" as applied to nuclear weapons is a descriptive word which refers to a hollow sphere made of metal which is the intermost part of the bomb and is necessary to start a nuclear reaction. The term "sealed" is used to indicate that the pit has no opening to the outside of the bomb, but is a complete sphere and is closed to atmospheric pressure.

The principal difference between the sealed pit weapon and the older types is in the composition of the "pit." The pit walls of new weapons were made of a very thin layer of active material, whereas the older type pit walls did not contain active material. To the pit is connected, by a small pipe, a cylinder of active gas. This is known as the gas boosted principle and replaces the capsule ball. The desired nuclear reaction of a nuclear weapon is obtained as a result of simultaneous squeeze of active material for a specific period of time. These requirements are not as critical in the older weapon as they are in the new sealed pit types. Therefore, the older weapon may produce a nuclear yield if fired by some other means than the weapon circuit, whereas the new sealed pit will not. Should the weapon explode as a result of impact or fire the explosion will be from the high explosive content of the weapon, not the nuclear material. Hence, the sealed pit weapon is considered "one point safe." (Info from DF, Armt Elec Div, D/M, to OI, Attn: OIH, "Information for History of Nuclear Weapons," 3 Oct 1958, filed in OIH, Hq SAC. For an historical summary of SAC nuclear weapons and their characteristics see Chart, "Summary of Nuclear Weapons . . .," Sec II; See also History of 8AF, Jan-Jun 1958, Vol I, pp 165-208, filed in OIH, Hq SAC, for additional information on sealed pit weapons.

From SAC History, 01-06, 1958.

Downloaded from: http://www.nukestrat.com/us/afn/SAC01-0658.pdf

The reservoir

Sometimes the reservoir is called a T bottle in the documents. After the Thule accident, all four reservoirs were recovered near the impact point. Because the tritium in reservoirs decays, a reservoir has to be periodically replaced. This exchange is normally performed at the weapons storage and maintenance site. As a result, the reservoir is located outside the 'physics package' (alternatively, the nuclear explosives package), i.e., the sealed portion including the primary/fission trigger and the secondary/thermonuclear stage. At the proper time for weapons arming, the deuterium-tritium (DT) gas moves via small-diameter tubing from the reservoir to the primary.

The maybe somewhat exposed location of the reservoir outside the nuclear explosives package and its relatively low weight appear to offer an explanation for why all the reservoirs broke loose from the nuclear package right away and were found close to the impact point, whereas some of the heavy pieces of secondaries slid 2 miles or more on the ice, with an initial speed of perhaps close to 300 meters per second.

The bombs

U.S. Air Force Fact Sheet
MARK 28 THERMONUCLEAR BOMB

The Mk-28 'hydrogen' bomb, although first produced in 1958, is still an active weapon. It was designed to be carried by various fighter and bomber aircraft (F-100, F-104, F-105, B-47, B-52 and B-66). The '28' warhead was also used in Hound Dog and Mace missiles, which have now been discontinued. The Mk-28 is capable of a ground or air burst and may be carried internally or externally, with a free-fall or parachute-retarded drop, depending upon its configuration.

The Mk-28 employs the 'Building Block' principle, permitting various combinations of components:

B28EX: Carried externally by F-100, F-105 and F-4; no parachute.

B28RE: Carried externally; equipped with one 4-foot pilot chute and one 28-foot ribbon chute.

B28IN: Carried internally by B-52 and F-105; no parachute.

B28RI: Carried internally; equipped with one 4-foot pilot parachute, one 16.5-foot ribbon extraction chute, one 64-foot solid chute, and one 30-inch stabilization chute.

B28FI: Carried internally; equipped with one 4-foot pilot chute, one 16-foot chute and one 24-foot chute.

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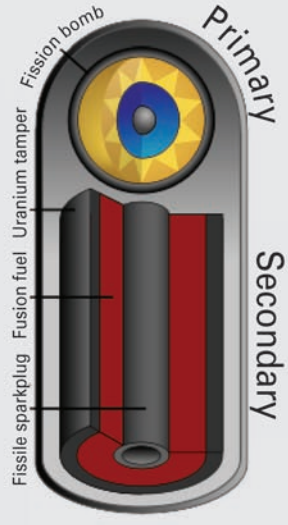

Thermonuclear weapon with primary and secondary, but without tail end. Teller-Ulam design.

The submersible

Star III in front of Scripps Institution of Oceanography, University of California, San Diego, La Jolla. The submersible was used in the underwater search in Bylot Sound in August 1968, where it performed eleven dives. The sources differ as to the average productive search time of each dive. Some say three hours, others one and a half.

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Table 1. Estimates of plutonium in four nuclear weapons 1968-1993

Appendix 2

Document	*Date*	*Description*	*Min. amount*	*Max. amount*	*Comment*
106915 (decisive lines excised) 107151 *107152* (hand-written notes) 107160 107151 and 107160 are nearly identical. The hand-written *107152* is the jewel among the three. Cf. analysis of these documents in chapter 3 under February 5.	05 February 1968	Meeting of the Safety Evaluation Panel chaired by Robert H. Parker. Langham presents early estimate of the amount of plutonium released in ice and snow on crash site. Only the handwritten version shows that it is Langham. Handwritten version is a key document in saying that the figure might be from 38% to +40% (may be up to 54%) of the total plutonium burden. These percentages reflect the underlying minimum, median and maximum estimates of kg plutonium in snow and ice, while the actual content of plutonium in the weapons is Langham's other known value.	About 38% of the total plutonium burden = low estimate of 2.5+0.3 kg. *100% = 7.4 kg* (author's calculation)	54% of the total plutonium burden = high estimate of 4.05 *100% = 7.5 kg* (author's calculation)	Danish and U.S. scientists agreed, according to doc. 107038, that the minimum amount in snow pack and blackened area could be estimated at 2.5 kg, the maximum at 3.7 kg. The amount in cracked ice area was estimated at between 0.3 and 0.35 kg. Using Langham's percentage figures, the corresponding amounts for 100 percent have been calculated by the author. We believe that the expression total plutonium burden is equal to the actual content of plutonium in the four weapons (in the primary pits).
RA, UM (Danish Ministry of Foreign Affairs), 93.USA.8.c., 01.02.68-29.02.68, pk. 2, fiche 2/6, doc. 70, Notits, Thulesagen, 5. februar 1968 (Notits 5/2 1968).	05 February 1968	Meeting in the Danish Atomic Energy Commission. Professor Kofoed-Hansen's estimate. Says that each of the bombs contained approximately 2 kg of plutonium.	~ 8 kg	~ 8 kg	This was the general perception of the Danish team according to a report by their American colleagues concerning cooperation among the two teams of scientists.

Document	*Date*	*Description*	*Min. amount*	*Max. amount*	*Comment*
RA, Forskningscenter Risø, Direktionen. 1968-1969. Materiale vedr. B-52 flystyrt i Grønland. Udskrifter af log mm., pk. 108, læg 3 (Aarkrogs dagbog).	21 March 1968	Asker Aarkrog's diary from Thule. Aarkrog cites the U.S. health physician Jim Olsen from Lawrence Livermore. About total amount of plutonium in the bombs: Less than the 7-8 kg surmised by the Danes, rather 5-6 kg.	5 kg	6 kg	Aarkrog sent the same information in telegrams to the Danish Atomic Energy Commission. (RA, Atomenergikommissionen. 1961-1976, Journalsager, pk. 271), (Aarkrogs dagbog). Olsen's information clearly reflected the amount declassified in Washington 10 days earlier: App. 6 kg involved in the accident.
Department of Energy (DOE).	xx-01-1994	In 1994 DOE declassified the fact that a quantity of 4 kg of plutonium was enough for the pit (of a modern primary) Quote: jj. Hypothetically, a mass of 4 kilograms of plutonium or uranium-233 is sufficient for one nuclear explosive device. (94-1) (See also II.M.30.a.).			DOE has not declassified information about plutonium in the old warheads of the sixties, in which there was less plutonium.
World Inventory of Plutonium and Highly Enriched Uranium 1992, SIPRI, Oxford University Press 1993.	xx-xx-1993	Quote: In 1965, the amount of plutonium per warhead averaged only 2 kg; but currently it averages about 3-4 kg per weapon. p.50).	~ 8 kg	~ 8 kg	The low amount of plutonium was made possible by adding weapons grade uranium, uranium 235, to the plutonium in the pit. The average content of uranium 235 per warhead in this period was 16 kg. U-235 was contained both in the primary and the secondary, maybe ~ 1:1. That would leave ~8 kg U-235 to mix with the plutonium in the primary pit.

LEGEND:

Content is used for further calculations

Table 2. Estimates of plutonium dispersed in the Thule accident 1968

Appendix 3

Document	*Date*	*Description*	*Min. amount*	*Max. amount*	*Comment*
1) 107151 2) RA, 1129, AEK (Danish Atomic Energy Commission), 1961-1971, Journalsager 1966-1971, pk. 269	05 February 1968	1) In oxide smoke, widely dispersed. Estimate of the Safety Evaluation Panel. 2) Some Radiological Aspects of the SAC B-52G Bomber Crash at Thule Air Force Base, Greenland.	1 kg	2 kg	Langham on the mechanism: Undoubtedly, the […] cloud and the accompanying plutonium traveled hundreds of miles and settled out over a vast area, producing extremely low surface plutonium levels.
107038	19 April 1968	Cracked ice area.	0.3 kg	0.35 kg	Included in the amount for sea bottom deposits below.
107038	19 April 1968	Blackened area, snow-pack. Based on various measurement methods on site.	2.5 kg	3.7 kg	Danish and American scientists in agreement on these minimum and maximum amounts. Nearly all is said to have been recovered. Plutonium that was not removed would show up in the measurements of sea bottom sediments.
107038	19 April 1968	In oxide smoke, local area.	0.16 kg	0.16 kg	Gjørup - value only for airborne residue in local area.
107117	09 June 1969	Estimate of plutonium content in the 315 jet engine containers with ice and snow returned to the U.S. and processed at Savannah River. The estimate is based on measurements of solid debris after filtration of the water in 225 out of a total of 315 containers.	2.2 kg	3.9 kg	The estimate is a prediction for the total content of all 315 containers, and corresponds well with the estimates produced on the site in Thule. The exact measurements from Savannah River for the whole process of filtration have not been released.

Document	*Date*	*Description*	*Min. amount*	*Max. amount*	*Comment*
Langham Trip Report	01 March 1972	In fire-blackened snow-pack.	3.2 kg	3.2 kg	Claims nearly all recovered.
Langham Trip Report (Langham 1972).	01 March 1972	In crushed and refrozen ice at impact point.	0.35 kg	0.35 kg	Not recovered - released to the sea - Included in the numbers for sea bottom deposits.
Langham Trip Report (Langham 1972). Langham at meeting with Danish scientists (AEK 18-19/3 1968)	01 March 1972	Impinged into the aircraft wreckage; weapons debris. Author's estimates here are only for recovered parts taken back to the U.S. Langham at meeting with Danish scientists in Washington said perhaps 5% of total impinged into aircraft debris.	0.2 kg	1.0 kg	Some of this plutonium was brought back to the U.S., some of it measured on the sea bottom. Here we venture a pure guess for the weapons and aircraft debris taken back to Rocky Flats and Oak Ridge. We know that Rocky Flats was ordered to measure the weapon parts, but have not seen the results. It is very possible that our maximum assessment is too low.
Langham Trip Report (Langham 1972).	01 March 1972	Blown beneath the ice	?	?	These amounts are covered by the amounts measured on the sea bottom
92267	23 August 1976	Plutonium on sea bottom - in sediments.	25 Ci 0.4 kg	30 Ci 0.5 kg	Aarkrog. Amounts covered in row below
1) Sven P. Nielsen and Per Roos: Thule 2003 Investigation of Radioactive Contamination. Risø-R-1549 (Nielsen & Roos 2006). 2) Mats Eriksson: On Weapons Plutonium in the Arctic Environment (Thule, Greenland), Risø-R-1321(EN), 2002 (Eriksson 2002).	01 May 2006	Plutonium on sea bottom - in sediments. Various estimates. The wide gap reflects the difficulties of doing representative sampling.	0.5 kg	3.8 kg	Sven P. Nielsen and Per Roos have the interval 0.5 kg - 2.0 kg. Mats Eriksson has the interval 6.7 Tbq - 10 Tbq - 13.2 Tbq, but thinks that this may underestimate the real amounts. From Eriksson's figures and considerations, we have chosen his median value of 3.8 kg, which he considers may still be on the somewhat cautious side, as our maximum value.

Document	*Date*	*Description*	*Min. amount*	*Max. amount*	*Comment*
Mats Eriksson et al.: U, Pu, and Am Nuclear Signatures of the Thule Hydrogen Bomb Debris, Environ. Sci. Technol., 2008, 42 (13), pp 4717–4722 (Eriksson 2008).	05 June 2008	The fissile material in the pits of the primary stages of the weapons involved in the Thule accident was a mixture of highly enriched uranium and weapons grade plutonium, and the main fissile material was 235U (maybe four times higher mass of 235U than of 239Pu). 4:1 is the relationship in the U/Pu particles investigated by Eriksson a.o., but this can hardly be taken as an accurate indication of the mix in the pits.			We are certain that the primary pits consisted of a mixture of uranium and plutonium. This is confirmed in the sanitized document collection. Incidentally, it is a so-called unclassified fact that plutonium and uranium may be bonded to each other in unspecified pits or weapons (DOE, OSTI, see addendum). We do not think this was the case in these weapons. Rather, they had so-called composite pits.
Minimum and maximum assessments of total amount of released plutonium according to estimates or measurements (inherently inaccurate). Calculated as sum of amounts in the yellow boxes.			4.06 kg	10.86 kg	The figures should be compared with the most reliable estimates of the contents of plutonium in the four weapons, which, as shown in Table 1, seem to gravitate towards 7.5 kg. Some of the minimum and maximum assessments are obviously wrong, but which ones, and by how much?

LEGEND:

Content is used for further calculations