and Iraqi-made airframe was launched from Um Qassir toward Ar Rutba. The separation was successful and the warhead landed in the designated target area at a range of 850-870 km[19]

Al Tamouz

The Al Tamouz missile project had as its aim the development of a missile with a range of 2000 km and a payload of 200 kg. The design comprised a two-stage missile consisting of one SCUD as a first stage and one SA-2 sustainer rocket as a second stage. Iraq declared that the programme started in May 1989 and was terminated two months later in July 1989.[20] Iraq[21] claimed that only paper studies had been made, although General Ra'ad stated during a meeting in April 1996[22] that a "mock-up" of the Al Tamouz had been built to show to General Hussein Kamel and General Amer Al Sa'adi and was later dismantled. Among the reasons cited for the abandonment of the programme were problems with the stage separation and inability to place a guidance system on the second stage[23]. Additionally, General Sa'adi was not keen on the concept, believing that it would not fly.[24]

Al Abid Space Launch Vehicle

As declared by Iraq[25], Al Abid was a project to design and manufacture a space launcher capable of putting a satellite into orbit and was an entirely civilian project. The project commenced in 1988 around the end of the Iran/Iraq war. The programme's declared name was Al Abid, but alternate names such as Bird (Al Ta'ir in Arabic) or Comet were also used, particularly early on. The project was carried out under the auspices of MIMI and involved scientists from Iraq's Space Research Centre, who had built a 50 kg test satellite and engineers from Project 144, primarily Project 144/2, to develop a launch vehicle, as well as other support groups. According to General Amer Al Sa'adi, though, there was no steering committee for the programme.[26]

Iraq had initially considered a joint venture with a foreign country to have their satellite launched[27] but when this did not work out a decision was made to develop its own launcher. To assist Iraq's engineers, in mid-1988, Space Research Corporation (SRC), and another team of two specialists were engaged separately for technical support. Their task was to prepare independent studies for a space launcher capable of delivering a 100-300 kg payload to a low earth orbit (about 200-500 km altitude). The delivery system had to be produced using assets already existing in Iraq, mainly SCUD 8K14, versions of

[19] Missile CAFCD 2002, chapter 5 (144/2), para 3.4.5.3.
[20] Missile CAFCD 2002, chapter 4, Al Tamouz.
[21] UNSCOM report 85, Sitrep 9, 19 July 1994.
[22] UNSCOM report 137, section 2, interview with Gen Ra'ad.
[23] UNSCOM report 85, BM-27, July 1994.
[24] UNSCOM report 137, section 2, interview with Gen Ra'ad.
[25] Missile CAFCD 2002, chapter 4, Al Abid and in all interviews on the subject.
[26] UNSCOM fax dated 8 Apr 1996. Interview with Gen Sa'adi on 7 Apr 1996.
[27] UNSCOM report 42 (BM 13), 7-18 Aug 1992. Answers given to UNSCOM report 42 questions, no. 3.

indigenously modified SCUD and SA-2 liquid propellant missiles. The SRC had also been working on the development of the Supergun (see Chapter IV.VII).

A number of design configurations were studied by SRC. Among the initial design options studied were configurations based on 4, 5 or 6 extended burn-time SCUD rockets as a first stage clustered around another extended burn-time SCUD as second stage, with a specially designed solid propellant rocket as the third stage.[28] Another study focused on various configurations using 5 or 7 SCUD-based rockets as a first stage, separated from a second stage modified SCUD rocket by an inter-stage mechanism, and a specially designed rocket for the third stage.[29] By early 1989, the SRC proposals had apparently converged on a design comprising 5 clustered modified SCUDs for the first stage; another modified SCUD for the second stage and a double-base propellant rocket for third stage.[30]

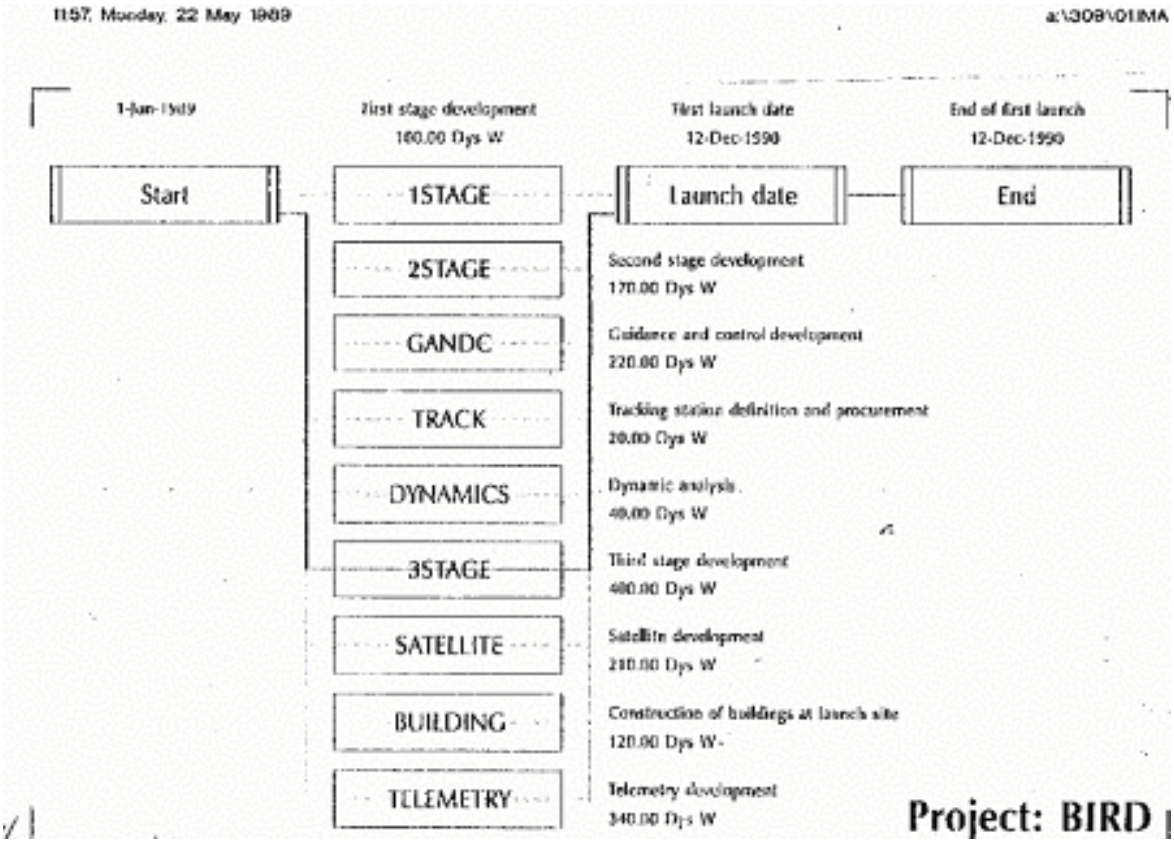
The other team of two foreign specialists provided the results of their studies in two reports[31, 32] in February 1989. Their studies were based on design configurations comprising a modified SCUD rocket with strap-on rockets of either four or eight SA-2 liquid propellant rockets or four or eight SCUD rockets. Both a liquid propellant and a solid propellant second stage were considered and a representative apogee motor was used for their parametric calculations. Iraq's engineers did not pursue launcher designs based on these configurations, apparently preferring SRC's proposals.

Following their initial studies, SRC made a proposal to achieve an earliest possible first launch test by setting up a team of approximately 35 professional staff to work with the other Iraqi team.[33] According to a senior Iraqi, though, there was no formal contract with SRC for the launcher's development, unlike the case with the Supergun. However, SRC personnel continued to be closely associated with the Al Abid project. It was stated that technical support was requested and paid for as needed.[34]

A proposed schedule was presented by SRC for the development of the Al Abid, as shown in Figure IV.III.XIX, which would achieve a first launch by 12 December 1990.

[28] SRC document, "Preliminary Proposal for Satellite Launcher Using Clustered Sadam Rockets". (internal document).
[29] "Project Bird", SRC document. (internal document).
[30] "Project Bird Status Report", SRC-TR-89852, May 1989. (internal document).
[31] "Analysis of SCUD-B Based Rocket with Volga Based Strap-On Boosters, Report No. C-89/001, 1989. (internal document).
[32] "Preliminary Study Regarding Future Space Carrier Vehicles", report No. C-89/002. (internal document)
[33] SRC document, "Preliminary Proposal for Satellite Launcher Using Clustered Sadam Rockets". (internal document).
[34] UNSCOM report 45, 29 October 1992. Meeting with Mr Hossam Amin. (internal document).

Figure IV.III.XIX Work plan proposed by SRC for an Al Abid launch by 12 December 1990.



Whilst receiving external support, Iraqi specialists from Project 144 were working on their own designs. Several sets of drawings were provided to UN inspectors from the Haidar farm, all of them produced by Project 144/2 between 1989 and 1990, which depicted various versions being considered for the Al Abid. Two of them are presented in Figures IV.III.XX and XXI. The modified arrangement of the jet vanes for the cluster of five SCUD engines is shown in Figure IV.III.XXII.

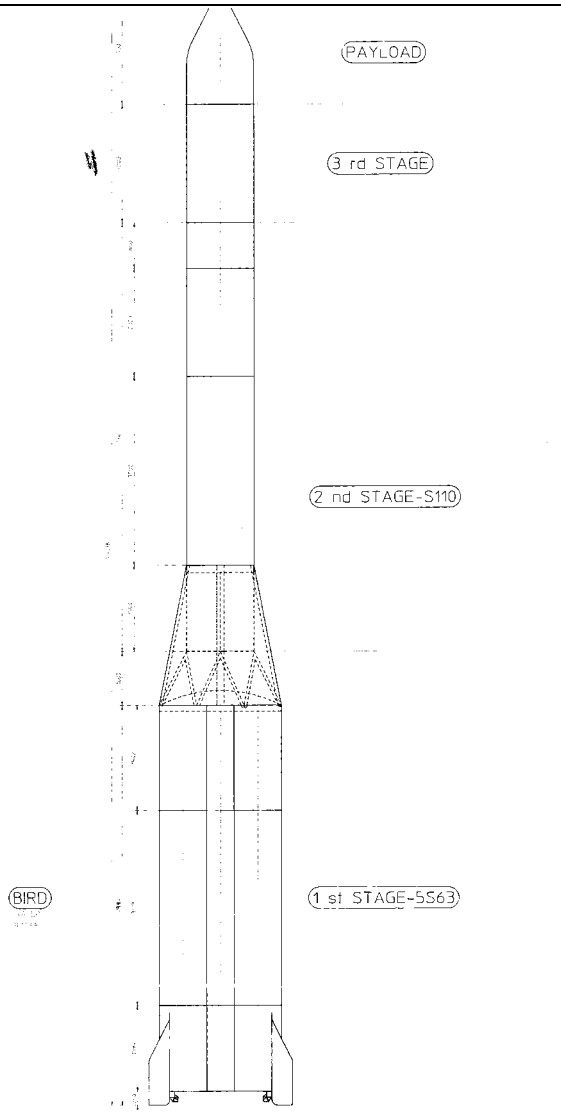


Figure IV.III.XX Version of Al Abid space launch vehicle, dated 9/11/88:
First stage - cluster of 5 SCUDs
Second stage - 1250mm diameter
Third stage - 1250mm
Payload -1250mm diameter

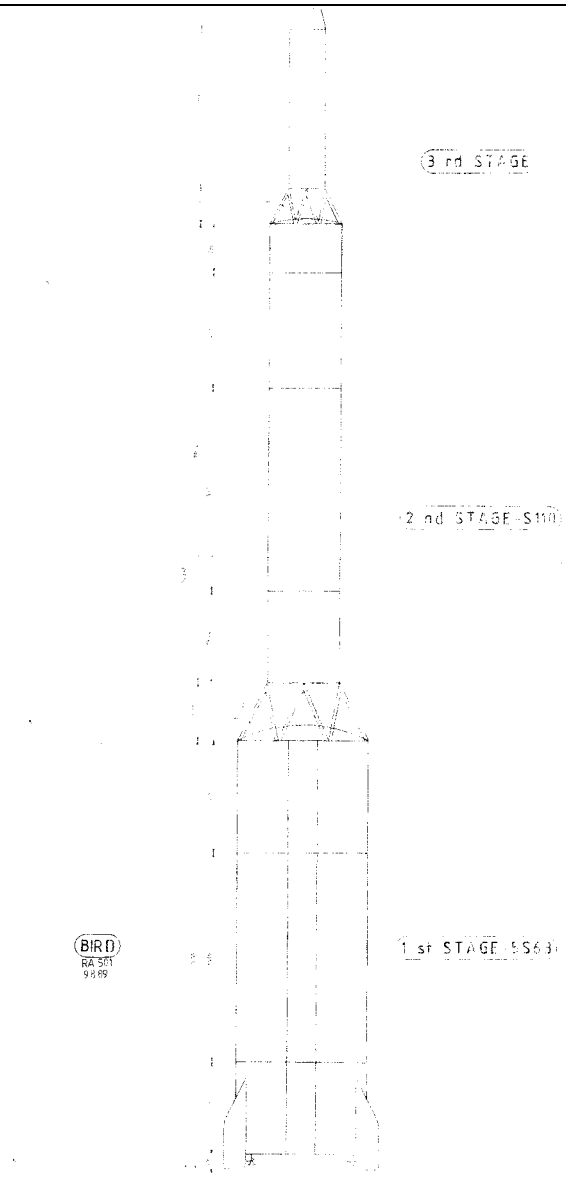
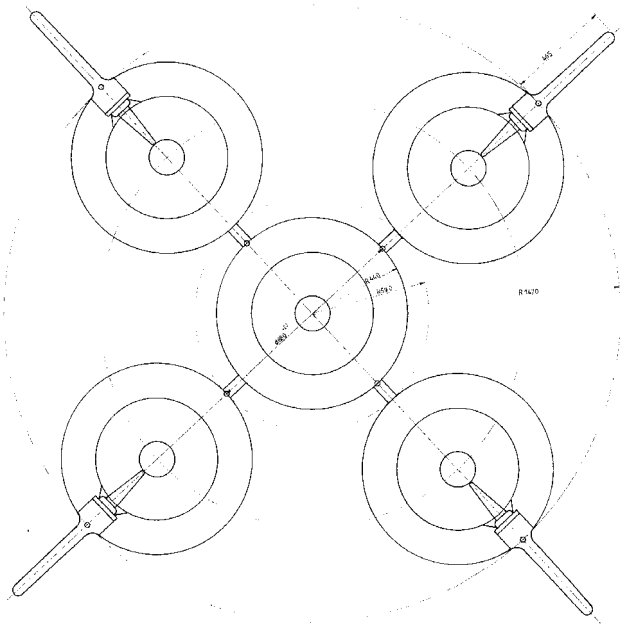


Figure IV.III.XX I Version of Al Abid space launch vehicle, dated 9/8/89 (similar to the version tested)

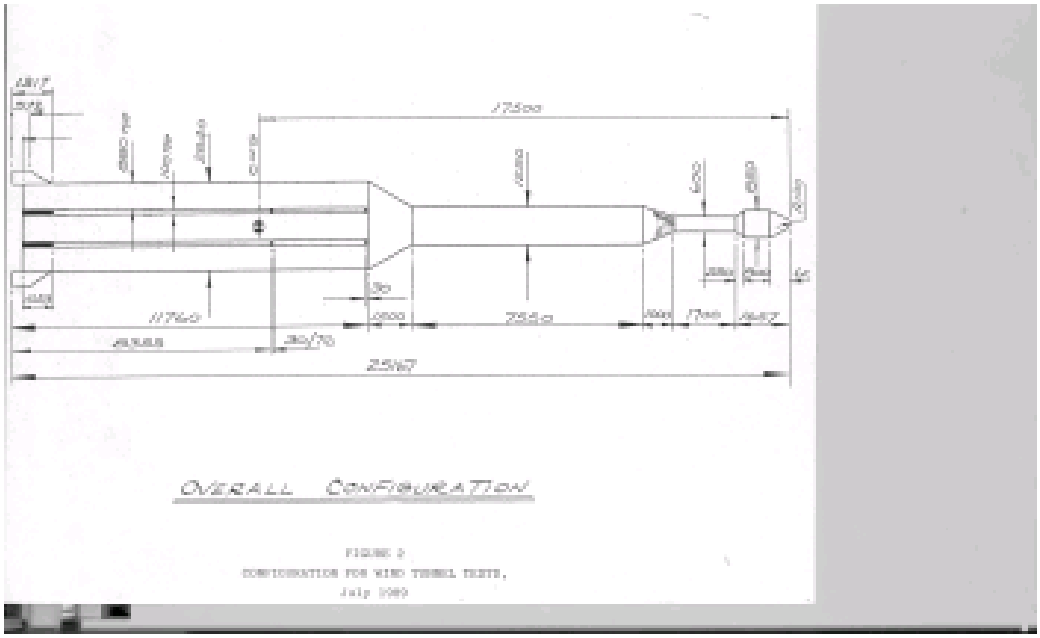
Figure IV.III.XX II Configuration of Al Abid first stage showing jet vane arrangement



The Iraqi drawing above, Figure IV.III.XXI, dated 9/8/89, is very similar to a configuration produced by SRC, shown in Figure IV.III.XXIII and dated July 1989.[35]

[35] Project Bird. Aerodynamic Calculations Progress Report, SRC-TM-89872, September 1989, Fig 2. (internal document)

Figure IV.III.XXIII Al Abid design configuration produced by SRC, July 1989.



With regard to the payload housing, at the beginning the diameter of the third stage was insufficient to fit the satellite. SRC suggested using an enlarged shroud, as shown in their design drawing in Figure IV.III.XXIII. General Ra'ad proposed a solution with the second and third stage having the same diameter that is, 1250mm, as shown in the Iraqi drawing, Figure IV.III.XX. For this configuration, General Ra'ad designed a clamshell type shroud that was separable from the third stage by explosive bolts.[36]

The basic vehicle design configuration chosen by the Iraqis by mid-1989 consisted of five clustered, extended burn SCUD engines for the first stage and a 1250mm diameter liquid propellant rocket for the second stage. It is unclear if details of the third stage rocket had been determined at that time, although some evidence points to use of another modified SCUD.[37] The major effort at the time was on the first and second stages.

The first test launch of the Al Abid occurred in December 1989[38] at the fixed launch site that had been constructed at Al Anbar. The test took place only six months after the SRC delivered their timeline proposal and 12 months before their proposed test launch date. However, only the first stage of the vehicle tested was operational, while stages two and three were steel mockups. A videotape of the test retrieved from the Haidar Farm showed that the first stage of five clustered SCUD missiles was working successfully until the

[36] UNSCOM report 137.
[37] e.g. 3rd stage diameter had changed to 880 mm by Sep 1989: Project Bird, Aerodynamic Calculations Progress Report, SRC-TM-89872, Sep 1989. (internal document).
[38] Missile CAFCD 2002, chapter 5 (144/2), para 3.4.9.

vehicle exploded at 45 seconds. Iraq suspected that the explosive bolts that were being used to effect stage separation functioned prematurely. Photographs of the test vehicle being prepared for the test launch are shown in Figures IV.III.XXIV and XXV.

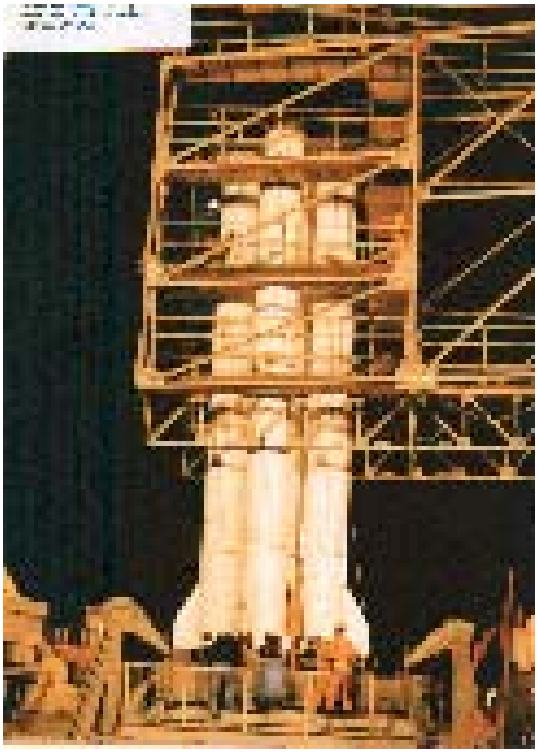


Figure IV.III.XXIV Al Abid under assembly at Anbar space launch pad

Figure IV.III.XXV Al Abid ready for launch at Anbar space launch pad

The fast development of Al Abid first stage could be explained by the extensive foreign support received. But also, General Amer Al Sa'adi had put General Ra'ad, the manager of Project 144/2, in charge of the airframe group developing Al Abid. General Ra'ad was well known for his practical approach in modifying and developing different versions of the SCUD and his expertise was a key factor in successfully clustering five SCUDS.

While primary concentration in the initial flight test was on validating the first stage, work for the second and third stages had also commenced. In the initial design studies undertaken by SRC, the second stage was to be a SCUD with an extended burn-time but with the standard airframe diameter of 880mm. However, by the beginning of 1989 the diameter of the second stage had been increased to 1250mm.[39] General Ra'ad who was in charge of the airframe design in Project 144/2 stated in 1996 that this change had come

[39] Project Bird – II, Further Iteration Studies of System Orbital Capability, SRC-TR-89832-A, Feb 1989. (internal document).

about through discussions with the Al Abid work team headed by General Amer Al Sa'adi.[40] General Sa'adi himself said in another interview that it had always been his intention that the second stage of the Al Abid space launch vehicle would be the basis of the delivery vehicle for a nuclear device (discussed below) and that this vehicle would have an internal diameter of 1250mm.[41]

The main problem that Iraq had with the second stage was that a standard SCUD liquid propellant engine produced only sufficient impulse to achieve their minimum requirements. SRC had highlighted through its early parametric studies that orbital capability, that is, heavier payload or higher orbit, was markedly more sensitive to changes in second stage performance than to changes in the first stage performance.[42] They proposed that the performance of the second stage rocket engine could be improved, firstly, by increasing the expansion ratio of the engine nozzle from 10 to 30 by addition of a nozzle skirt and, secondly, by changing the TM 185 fuel to diethylenetriamine (DETA) or a mixture of DETA and unsymmetrical dimethyl hydrazine (UDMH).[43]

As an alternative to improving the performance of the SCUD liquid propellant engine, Iraq had tried to import a more powerful engine. General Amer Al Sa'adi stated that he visited two foreign countries trying to purchase such an engine but he failed. Both countries offered their services to launch the satellite for Iraq but denied access to a more powerful engine.[44] Consequently, Iraq focused on improving the SCUD engine. Project 1728, headed by General Modher, was conducting work in parallel with the work done by Project 144/2, looking to improve the performance of Al Abid second stage engine. A test[45] was carried out on 1 Dec 1990 by Project 1728 that used a nozzle extension for increased expansion ratio and UDMH as fuel for higher energy. However, without any cooling to emulate a high altitude condition the skirt melted (Figure IV.III.XXVI) and the test failed after 14 seconds.

[40] UNSCOM report 137.
[41] Notes on discussions held by IAEA/UNSCOM at NMD on 5-6 Feb 1996, Missile Program. (internal document).
[42] SRC document, "Preliminary Proposal for Satellite Launcher Using Clustered Sadam Rockets", Summary, p 7. (internal document).
[43] e.g. in Project Bird Status Report, SRC-TR- 89852, May 1989, sections 3.1 and 3.2.3. (internal document).
[44] Interview held at NMD, 5-6 Feb 1996, paras 6-9. (internal document)
[45] Missile CAFCD 2002, chapter 5, 144/3 (1728 Project), appendix 5, Table 1.

Figure IV.III.XXVI SCUD engine test using UDMH fuel and a nozzle extension skirt.

In addition to investigating the use of UDMH, according to General Modher's statements[46], project 1728 was looking to further develop the capabilities of its engine design group and the Al Abid project provided a good opportunity for doing this. Iraq declared that they came up with the idea to use a new engine with four SCUD combustion chambers and a single turbo-pump for the Al Abid first stage. The new engine would fit the 1250mm airframe, and using a mixture of DETA and UDMH instead of TM 185 fuel would provide an alternative to the cluster of five SCUD missiles. General Modher contracted a former teacher of his from a foreign country to design the turbo-pump, designated as the HF turbo pump, capable of feeding the assembly of four SCUD combustion chambers. General Amer Al-Sa'adi gave the approval for this project just after the Al Abid test in December 1989. To fulfil a request from General Hussein Kamel, the same person had been contracted just prior to starting on the HF turbo pump to design a 30 tonne thrust liquid propellant engine, known as the HK engine. Ultimately, the primary designs of the HK engine and the HF turbo pump were made but they were not completed due to the onset of the 1991 Gulf War.[47] Another foreign company was

[46] UNSCOM report 137.
[47] Missile CAFCD 2002, chapter 5, 144/3 (1728 Project), para 3.11.

also contacted in mid-1990 to design and manufacture a similar turbo pump but again due to onset of the 1991Gulf War and its outcome this proposal went no further.

Following the partially successful test launch in December 1989, it was decided, according to General Ra'ad, that the combined second and third stages needed to be flight tested separately.[48] A test was scheduled for the autumn of 1990. This planned test was referred to as Al Kharief (meaning "Autumn").[49]

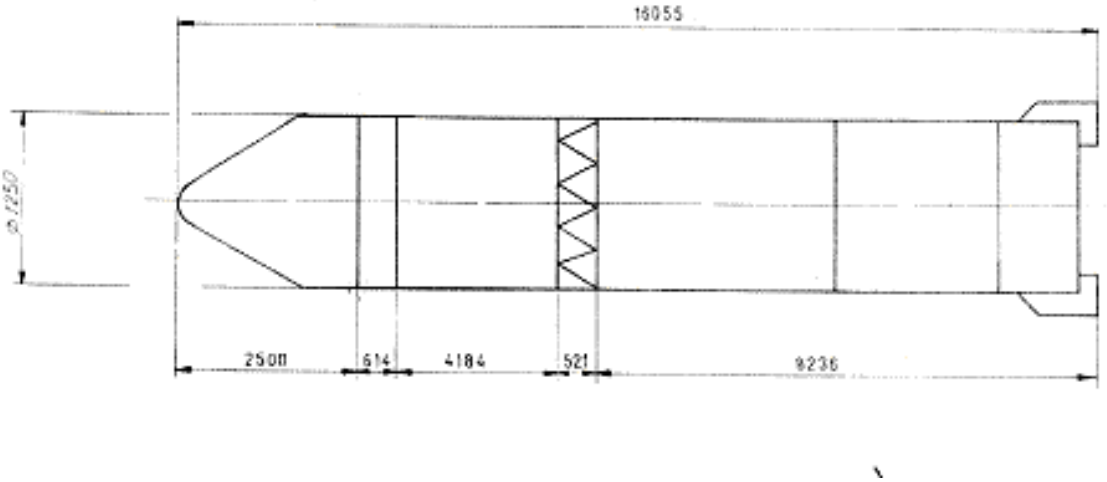
Al Kharief (alt. sp. Al Harith)

The planned flight test of the combined second and third stages of the Al Abid as a separate ground launch vehicle which was declared by Iraq as Al Kharief, together with information obtained during several interviews of key Iraqi personnel, led some UN inspectors to believe that Al Kharief was, in fact, a separate missile project. Iraq insisted in its Missile CAFCD that this was not the case.[50] Nonetheless, if the flight test had occurred, it would have served two purposes. At face value, it would have progressed the development of the Al Abid space launch vehicle but also, as discussed below; it would have contributed to the development of a delivery vehicle for the secret nuclear weapon.

In the work that continued after the December 1989, Al Abid flight test with its dummy second and third stages, effort concentrated mostly on development of the second stage of the Al Abid (first stage of the Al Kharief test vehicle). General Modher and his team (Project 1728) continued work, independently of General Ra'ad and 144/2, on improvement in performance of the liquid propellant engine and, additionally, on some airframe items, for example, thrust mounts for the 1.25 metre diameter airframe. General Ra'ad continued with his design work, basing his designs on the standard SCUD engine performance. Work on the 1.25 metre diameter airframe was well underway. Due to difficulties in manufacturing, General Ra'ad had placed orders with a foreign engineering company for 20 sets of 1.25 m Z rings for the second stage (10 sets ordered on 9 January 1990 and delivered, and 10 sets ordered on 28 March 1990 that were not delivered)[51]. In addition, end domes for the tanks were procured from abroad. According to General Ra'ad[52], two fuel tanks and one oxidiser tank were manufactured equipped with Z rings and longitudinal stiffeners, on the same principle as in the SCUD. A possible design configuration for the Al Kharief test vehicle, found in the Haider farm documents, is shown in Figure IV.III.XXVII.

[48] UNSCOM report 137.
[49] Missile CAFCD 2002, chapter 5, para 3.4.9.
[50] Missile CAFCD 2002, chapter 5, para 3.4.9.
[51] UNSCOM report 137.
[52] UNSCOM report 137.

Figure IV.III.XXVII. A possible design configuration of Al Kharief test vehicle



Around mid-1990, because the pace of the Al Kharief work was not proceeding quickly enough, and because General Hussein Kamel was pushing for completion of the work for an autumn launch, General Amer Al Sa'adi asked General Ra'ad to convene a meeting where all relevant parties would be represented and specific tasks assigned to each of them. The meeting took place on 17 June 1990. However, because different groups were in conflict with each other and there were other priorities, only Project 144 personnel actually turned up. Little further work occurred on the planned Al Kharief test (or other aspects of the Al Abid project) after this meeting owing to the invasion of Kuwait in August 1990 and subsequent events. General Ra'ad stated several times in interviews in 1996 that, to his knowledge, no results, no documents and no drawings were available in relation to Al Kharief and his work group wrote no final report.[53]

S 13 - The nuclear weapon delivery system.

In early 1987, Iraq started a programme to develop a nuclear explosive "device". This project had been initiated within the IAEC (Iraq Atomic Energy Commission) and undertaken by PC3 (Petrochemical Group 3 – a name given to disguise its real purpose).

According to General Amer Al Sa'adi, the first informal contacts to discuss the integration of the nuclear device with a delivery system had taken place in 1987 between himself and the IAEC.[54] Then on 7 May 1988, the first formal meeting was held between PC3 and the Director (General Hussein Kamel) and Deputy Director (General Amer Al Sa'adi) of MIC. At this meeting the IAEC gave the main data regarding the device. The weight was in excess of 2 tonnes and its diameter was 1.25 m; the range required was 650

[53] UNSCOM report 137.
[54] Interview held at NMD, 5-6 Feb 1996. (internal document).

km.[55, 56] As these parameters were beyond the capabilities of any of Iraq's existing missiles the meeting concluded that PC3 would endeavour to reduce the size and weight of the nuclear device as far as possible and MIC would develop a missile that could accommodate the eventual device. At that meeting, the chairman of the IAEC stated that a period of three years had been set for the programme.

Since the nuclear weapon project was a secret programme very few Iraqi specialists were informed about it. Only members of Group Four established within PC3 were aware of all the details of the work.[57] With the objective in mind of developing a delivery system, work was undertaken within other MIC missile activities that would lead to a suitable nuclear weapon delivery system. According to information provided in interviews, General Amer Al Sa'adi personally managed progress on this objective by ensuring that the direction and activities of missile work under his control catered for this secret project. During an interview in 1996, General Sa'adi was asked for information about the management of the nuclear delivery system and he responded that no document ever contained any reference to that purpose and that everything was only in his mind.[58] However, on 2 April 1989, an administrative order was issued by MIC for work on Project S-13. Based on information gathered during interviews[59, 60] and documentary evidence produced by Iraq[61], S-13 was the project most directly concerned with the long-term development of the delivery system for the nuclear device.

General Sa'adi declared to UN inspectors[62] that, following the May 1988 meeting; it was his view that it would take several years to develop a delivery system for the nuclear weapon, at least until 1993. He stated that even though the IAEC had indicated a three-year timeline at that meeting for completion of the nuclear device, that is, by 1991, he did not believe that the device would have been ready before 1993.

From the information gathered in numerous interviews with General Amer Al Sa'adi, General Ra'ad, the manager of Group Four in PC-3 and some other high ranking scientists involved, three options were pursued by Iraq for a nuclear delivery system:[63]

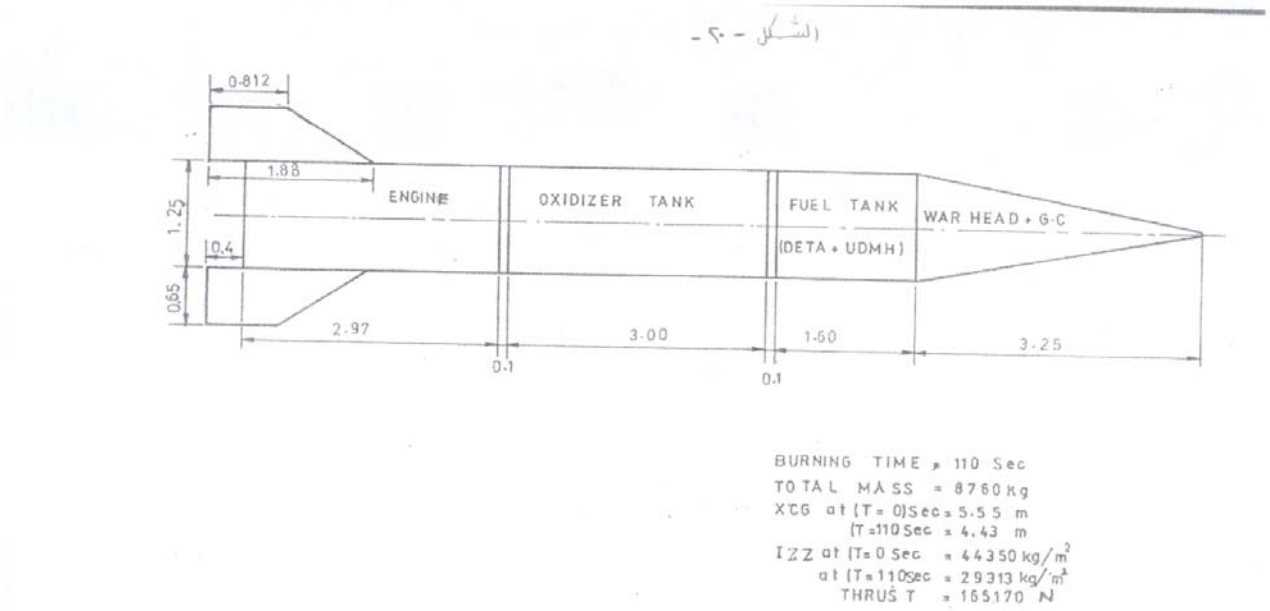
1. a missile with diameter 1.25 m capable of delivering a warhead of at least one tonne to a range of almost 1200 km ;
2. a derivative of the Al Hussein/Al Abbas missile designed to deliver a warhead of one tonne up to 650 km and to accommodate a nuclear package of 0.8 m diameter;
3. an essentially unmodified SCUD-B missile, accepting a range limitation of 300 km.

[55] Missile CAFCD 2002, chapter 5 (144/2) para 3.4.9.
[56] Interview held at NMD, 5-6 Feb 1996, p 5-6. (internal document).
[57] Interview held at NMD 5-6 February 1996. (internal document).
[58] Record of meeting held at NMD, 7 Feb 1996. (internal document).
[59] Interview held at NMD, 5-6 Feb 1996, p 5-6. (internal document).
[60] UNSCOM report 137 and missile CAFCD 2002, chapter 5, 144/3 (1728 Project), para 3.4.8.
[61] Calculation of project S-13 provided to UNSCOM EC on 1 Oct 1995. (internal document).
[62] e.g. Interview held with IAEA and UNSCOM inspectors at NMD, 7 Feb 1996. (internal document).
[63] cf. Record of meeting held at NMD, 7 Feb 1996; IAEA fax, dated 5 Mar 1996; UNSCOM fax to IAEA, S-10/96-71, dated 14 Oct 1996. (internal document).

Activities under these three options are described in the following paragraphs.

Option 1 – the long-term option
Following the administrative order issued in April 1989, work commenced on Project S-13. The exact purpose of this project was never explicitly declared. However, several reports were provided to UN inspectors. In one report[64], a design is given for a 1.25 m diameter missile with a payload of one tonne, as shown in Figure IV.III.XXVIII.

Figure IV.III.XXVIII Design of S-13 presented in the report issued on 7 August 1990



In the report, comparative reference is frequently made to Al Abbas characteristics, suggesting that S-13 may have been seen, at least by some, as an Al Abbas upgrade. The missile diameter and payload given in the S-13 reports, though, are consistent with the requirements for the nuclear weapon. The study results demonstrated maximum ranges between 850 and 1180 km.

In numerous interviews with UN inspectors, General Amer Al Sa'adi stated consistently that it had always been his intention that the second stage of the Al Abid space launch vehicle would be the basis for the nuclear delivery vehicle.[65]

[64] Report to Senior Deputy Director of MIC, "Calculations of Project S-13", 7 Aug 1990. (internal document)
[65] e.g. Interview held at NMD, 5-6 Feb 1996, p 6. (internal document)

Comment
In this context it is understandable why the diameter of the second stage of the Al Abid was changed from 0.8 m to 1.25 m around the beginning of 1989, as noted above in the description of Al Abid project. Furthermore, much of the activity undertaken under the Al Abid programme to improve the performance of the second stage can be readily seen as applicable to a nuclear weapon delivery system with a payload of one tonne.

As described in the Al Abid section above, Project 1728 was pursuing its own independent activities to improve the second stage performance through the use of more energetic fuels and alternative liquid propellant engine designs. General Ra'ad and his airframe team, Project 144/2, however, in the development of the Al Abid vehicle design undertook the mainstream activity. These activities included the responsibility given by General Sa'adi to General Raad after the June 1989 meeting to take overall responsibility for coordinating preparations for the Al Kharief test.

In interviews relating to his work on the second stage for Al Abid, however, General Ra'ad repeatedly stated that he was unaware of General Sa'adi's thoughts about using the second stage for a nuclear weapon delivery vehicle.[66] He also stated that no one ever approached him about using the Al Kharief concept as a surface-to-surface weapon.[67] When asked about S-13, General Ra'ad stated that this was a designator for Al Abbas.[68] He further stated that he never worked with a 1.25 m diameter under the S-13 name but that, to his knowledge, it was a study to improve the stability of the Al Abbas missile.[69] It was also declared by Iraq that the successful development of the Al Abid second stage could have also provided a long-term solution to improve the Al Abbas capabilities.[70] It is unclear if the S-13 project was portrayed as an improvement programme for Al Abbas, but development activities under the S-13 designation were, at least for General Sa'adi, essentially for achieving a long-term solution for a nuclear weapon delivery system.

Comment.
All the information provided to UN inspectors indicated that there were links between the development activities undertaken for the Al Abid second stage, the S-13 project and an improved Al Abbas, although the precise details of the relationships are unclear. What is clear, however, is that these activities were contributing to the long-term solution for a delivery vehicle for the nuclear weapon under the overall control or oversight of General Amer Al Sa'adi.

Option 2 – the "crash programme" option
Early in 1990 the Director of MIC, General Hussein Kamel, feeling that the PC3 project was taking too long, instituted a "crash programme" to rapidly complete the project.[71,72]

[66] UNSCOM report 137.
[67] UNSCOM report 137.
[68] UNSCOM report 137.
[69] UNSCOM report 137.
[70] Missile CAFCD 2002, chapter 5 (144/2), para 3.4.9.
[71] Missile CAFCD 2002, chapter 5 (144/2), para 3.4.9 and chapter 7, para 7.1.
[72] Interview held at NMD, 5-6 Feb 1996, pp 6-9. (internal document)

To hasten the development of the nuclear device, instead of following the normal path of uranium enrichment, he ordered the reprocessing of Iraq's safeguarded nuclear fuel. He also knew General Sa'adi's view that it would take several years to develop a delivery vehicle, but regarded this opinion as too conservative. Accordingly, in August 1990, General Hussein Kamel went directly to General Raad and told him to develop a system in a hurry. He was given a six months timeline. General Ra'ad assumed a device diameter of 880mm and a total payload weight of one tonne and with these requirements developed a preliminary design based on the original Al Abbas missile. With a maximum engine burn time of 103 seconds, he estimated a maximum range of 630 km. Because of the imminent outbreak of war the project did not proceed. In later interviews with UN inspectors, General Ra'ad defended his solution and its probability of success but General Sa'adi characterized it as unrealistic.

Option 3 – the fallback option
The only proven option that Iraq could have used as a "fall-back" option, as acknowledged by General Amer Al Sa'adi[73], would have been to use an existing 8K14 (SCUD-B) missile, since it had the capability of delivering a payload of one tonne, and to accept the range of 300 km.

Comment
This may explain why there were ten remaining SCUD missiles that Iraq did not modify to Al Hussein missiles.

Project 144/2 infrastructure

During the last quarter of 1986, a team was established that conducted feasibility studies on the reverse engineering of the SCUD (8K14) missile for the purpose of the indigenous manufacture of this type of missile in Iraq. In parallel, the Project 144 team was working to modify the SCUD missile in order to achieve a longer range. The two groups were put together to decide what the problem was with the failure of the modified SCUD that was flight tested in February 1987. One group said it was instability and the other said it was a guidance and control problem. Management knew they would have severe difficulty fixing the guidance problem and decided to go with the instability problem. The problem concerned the position of the center of gravity with the weight change and elongation of the missile. With this is mind, Project 144/2 worked on developing a design for the new missile. However, Project 144/2 had an inherent deficiency in the area of design capability, a prerequisite for effective reverse engineering efforts.

To overcome this shortfall, Project 144/2 established a small design section (less than six people) in September 1987 at the Central Tool Room Plant in the Nasser State Establishment. The Nasser establishment was selected because of its proximity to the Project 144/2 facility at Taji. The Project 144/2 design section relied upon the assistance of Nasser for the measurement of parts and the production of drawings. However, the Project 144/2 design team ran the entire effort, without Nasser knowing exactly what they

[73] Record of meeting held at NMD, 7 Feb 1996. (internal document)

were working on. They were strictly a supporting agency, providing Project 144/2 with administrative and logistical assistance as required (in addition to the design team at the CTRP, Project 144/2 maintained an administrative office at Nasser as well).

Reverse engineering had been a mission statement from the start of Project 144/2. From September to December 1987, this reverse engineering mission could be pursued in parallel with the ongoing modification development effort. As missile airframes were cut up for use in the conversion of other SCUD missiles to Al Hussein missiles, the materials were being analyzed and drawings made.

Together with the Project 144/2 leadership, the workshops attempted to identify the technologies required to produce the parts and components in question. While much information was gained through the examination of cannibalized parts, the tempo of modification dictated that the available time for access to these dismantled parts would be limited. In late August 1987, Unit 224 turned over to Project 144 a combat missile that had been filled in 1985 with fuel and oxidizer and was not fired and hence technically considered a non-combat missile. This missile was quickly disassembled, and its parts divided among the relevant workshops and research and development groups. The Engine Group received its initial combat engine for reverse engineering purposes at this time, but it was not from this missile; instead, the engine left over from the 21 April 1987 cannibalization was turned over, with Project 144 retaining this engine for future use.

Sketches concerning the extended airframe were made early on, and did not represent a major obstacle to the goals of Project 144/2. Of more concern were the reinforcement rings of the airframe and warhead. For these items, special attention had to be paid to the shape, radius and metal type (metal samples were sent to various establishments in Iraq for analysis). However, the requirements brought on by the impending "War of the Cities" forced the Director of Project 144/2 to cease all reverse engineering efforts by December 1987 in order to fully concentrate on the demands of mass modification. Only the small design team at Nasser continued to work on reverse engineering efforts, continuing as it did to conduct measurements and produce drawings using Nasser CTRP assets. Also, work on the warhead continued and a crude example of it was manufactured and tested on 24 February 1988.

At that time, Iraq had no one experienced in the cutting and welding of stainless steel used in the SCUD missile. They received assistance from the Daura refinery and began with a pipe-cutting machine for the circular cutting of the airframe. They eventually lengthened the missile by the use of a hand held argon welder. For alignment, they used theodolite devices and fine wire string. Initially it took fifteen to twenty days to accomplish the extension of the airframe.[74]

When UN inspections commenced in 1991, Building 16 at Taji was identified as one of eight Project 144/2 buildings. This building was not damaged during the war. It contained several standard, general-purpose drilling and riveting machines.

[74] Missile FFCD 1996, para 3.4.5.1.

Building 18 was also part of Project 144/2. It was the assembly facility for the Al Hussein missile, with indigenously produced, rather than modified SCUD, propellant tanks. UN inspectors at this building observed fourteen SCUD fuel tanks, all damaged or destroyed, and several pieces of damaged surveying equipment used to align components during assembly.

Building 21 was also part of Project 144/2. This building was the welding shop of Project 144/2, where Al Hussein propellant tanks were produced from end domes, which were made at the Al Nasser State Establishment and from cylinders produced in Project 144. They also produced sea mines, made by welding together domes identical in size to those used to produce SCUD/Al Hussein tanks, but made of ordinary steel rather than stainless steel. Over 100 corroded, but undamaged sea mine domes and several damaged missile propellant tank sections were found.

Building 22 was also part of Project 144/2. In this building the Iraqis produced the propellant tank inserts that were used to make Al Hussein missiles from SCUDs. One hand held welder and a cutting and drilling machine were found, but they were all completely damaged beyond repair. The building was also completely destroyed.

Building 24 was also part of Project 144/2. It was basically the SCUD receiving facility where the missile would be disassembled and the pieces would be sent out to the other Project 144 areas. Once the other Project 144 areas completed their work, the pieces would come back to building 24 for reassembly. Various UN teams found evidence of indigenous production of Al Hussein warheads and fuse components in this building. In addition, UN teams found three heavily damaged missile-carrying racks and destroyed pieces of missile turning and handling equipment.

Building 111 was also part of Project 144/2. It was where the Iraqis formed and welded from stainless steel sheets the cylinder sections used in Al Hussein propellant tanks. Fourteen damaged or destroyed cylinder sections, two destroyed forming machines and three destroyed welding machines were observed.

Building 112 was also part of Project 144/2. It was the storage building for propellant tank cylinder sections. Although the building was almost completely destroyed, 15 intact cylinder sections could be seen under the rubble. Several heavily damaged or destroyed cylinder sections were also scattered about the building.

Building 113 was also part of Project 144/2. This building was used for missile disassembly and reassembly. One intact propellant tank and several destroyed tanks were observed.[75]

[75] UNSCOM report 3, July 1991, para 10.2.