Appendix B

Soviet Space Stations: Achievements, Trends, and Outlook

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> My mathematical conclusions, based on scientific data verified many times over, show that with such devices it is possible to ascend into the expanse of the heavens, and perhaps to found a settlement beyond the limits of the Earth's atmosphere. . . . People will take advantage of this to resettle not only all over the face of the Earth but all over the face of the Universe. . . .
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> –K. E. Tsiolkovsky 1903

It is a widely held belief that the Soviet space program deliberately follows the paths described in the early years of the century by Konstantin Tsiolkovsky.[1] Be that as it may, it is certainly possible to find close parallels between Tsiolkovsky's writing and the course of events, but more likely these parallels result because modern engineers have arrived at similar solutions to the same problems rather than because of slavish obedience or preconceived notions.

Smolders[2] holds that the concept of space stations forms the nucleus of Tsiolkovsky's vision of space travel, Tsiolkovsky considered the construction of a permanent base in space to be the first important step towards a landing on the Moon and exploration of the planets. A space station concept attributed to Tsiolkovsky depicting a closed ecological system and garden, laboratories, living quarters, and a docking port with an airlock has been reproduced in official Soviet publications. Illustrations of other space stations appearing on commemorative stamps owe more to the designs of Shternfel'd and others which are to be found in a handbook produced by the staff of the Battelle Memorial Institute. ' A 1964 Soviet Defense Ministry book on Manned Space Stations listed the building of a larger manned space station, with a crew of 30 to 50, in the 1972-75 period, as the third of five further stages in space conquest.[4] To date, the maximum number to man a complex at any one time has been five for the Apollo-Soyuz mission and two visits to Salyut 7.[5]

After the "troika" mission of Soyuz 6, 7, and 8 in 1969, Leonid Brezhnev said, "Soviet science views orbital stations with interchangeable crews as man's major highway into space. . . . Major scientific laboratories will appear for conducting research in space technology and biology, medicine and geophysics, astronomy and astrophysics. "[6]

According to Feoktistov and Markov, direct work on Salyut space stations began in 1969.[7] To reduce cost and to shorten the construction time as many units and separate systems as possible were used from Soyuz, Zond, and other tried and tested designs. Most of these needed modification as they did not provide the required service-life, and basic systems, such as the heat supply, were built from scratch. The intention of using the manned mode opened up the possibility of in-orbit repair and replacement of defective subsystems, thereby increasing the reliability and life of the station.

A study of Soviet space station philosophy demands consideration of Salyut, Soyuz, and Progress spacecraft as components of an orbital complex. The Soyuz acts as a manned transport craft between Earth and the orbiting space station, remaining docked with the station whilst the crew is on board, in the same manner as the Apollo was used for three missions to Skylab and, presumably, the Shuttle orbiters will be used with any future National Aeror autics and Space Administration (NASA) space station. Progress, a Soyuz derivative, has an unmanned role as an expendable cargo vehicle.

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[1] V Rich, *Nature* **250 (London** July *19, 1974)*, p 177

[2] PL, "Soviets in Space" (Guildford Lutterworth Press, 1973), p 34

[3] G E Wukelic (ed) *Handbook of Soviet Space-Science Research*, Gordon and Breach New York 1968 pp *473-486*

[4] I N Bubnov and L N Kaminin, "Manned Space StatIons," *Voyennoye Izdatel'-stvo Ministerstva Oborony SSSR* (Moscow *1964)* and quoted in M Stoiko, "Soviet Rocketry, ' p *209*

[5] *Apollo*, Thomas Stafford, Donald Slayton, and Vance Brand. *Soyuz*, Aleksey Leonov and Valeriy Kubasov Docked 1309 Z, July 17, 1975. First undocking 1203 Z, July 19.37 min. undocked. Second docking 1240 Z, July 19 Final undocking 1526 Z, July 19, 50 hr 17 min. total, 49 hr. 40 min. net, *Soyuz-T 5*, Anatoliy Berezovoi and Valentin Lebedev. *Soyuz-T 6*, Vladimir Dzhanibekov, Aleksandr Ivanchenkov, and Jean-Loup Chretien. Docked 1746 Z, June 25, 1982. Undecked 1101 Z, July 2, 161 hr 15 min. total. *Soyuz-T 7*, Leonid Popov, Aleksandr Serebrov, and Svetlana Savitskaya. Docked 1832, Aug. 20, 1983. Undecked 1145 Z, Aug 27, 161 hr. 13 min. total.

[6] Brezhnev's statement quoted by A. S. Yeliseyev at press conference following end of manned phase of the Salyut 6 mission, reported in *Izvestiya*, July 14, 1981, p. 2, reproduced in JPRS 70319, Space #13, Oct. 28, 1981, p 4

[7] K. P Feoktistov and M. M, Markov, "Evolution of 'Salyut' Orbital Stations, " Zemlya i Vselbnnya, 5, September-October 1981, pp. 10-17, reproduced in JPRS 80424, Space No. 15, Mar 29, 1982, p. 1

Although certain events in the history of the Soviet space program have been spectacular at the time, it must be realized that they are not instant technological breakthroughs but rather are the results of careful planning and cautious steps towards the desired goals, The docking of the Soyuz 4 and 5 spacecraft in 1969, claimed as establishing "the world's first orbital space station,"8 should be seen as the first docking of two manned Soviet spacecraft following two successful automatic dockings of unmanned satellites in the Cosmos series.[9] The clue to the intended function of the Soyuz was to be found in the name "Union," although a characteristic element of ambiguity was also present. The EVA transfer of cosmonauts between the two spacecraft demonstrates the step-by-step approach and unsophisticated design philosophy.[10] Internal crew transfer was not accomplished until Soyuz 11 docked with Salyut 1 more than 2 years later.

The Soyuz T (T = transport) currently in use with the Salyut 7 space station has evolved through several variants. Tested unmanned in the Cosmos series, Soyuz 1 malfunctioned and killed cosmonaut Komarov during the return to Earth when the parachute failed to deploy correctly. " This resulted in an 18-month period of redesign before testing recommenced with the unmanned rendezvous and docking of Cosmos 186 and 188. As in Voskhod, crews flew without spacesuits and a three-man capacity was demonstrated with Soyuz 5 although, for the Soyuz 9 recordbreaking 18-day flight, the crew was reduced to two to permit sufficient consumables to be carried. The loss of the crew of Soyuz 11 returning from the 24-day mission to Salyut 1 necessitated a further period of redesign.[12] To accommodate a life-support system and a spacesuited crew, one of the seats was removed and Soyuz flew as a two-man spacecraft for the remainder of its life, ending with Soyuz 40 in 1981.[13]

Prior to this, unmanned flights in the Cosmos series, having characteristics similar to those of manned missions, pointed to the development of a new manned spacecraft. 14 It was mildly disappointing when, on its first flight to the Salyut 6 space station at the end of 1979, it **was** named Soyuz T and then shown in photographs to have the same external shape and dimensions of the old Soyuz.[15] Internal redesign has restored the three-man capacity,[16] whilst permitting the use of spacesuits at critical phases of the mission, and an onboard computer has enhanced its performance. Whereas the early Soyuz spacecraft were stated to have a 30-day capability, Soyuz T 5 functioned in orbit for 106 days, during which it was docked with Salyut 7 for 103 days.[17]

A major disadvantage of using the Soyuz appears to be the tight constraint imposed by lighting conditions during recovery, Information released at the time of the Apollo-Soyuz Test Project (ASTP) revealed that landings should occur at least 1 hour before local sunset and that a minimum of 8 minutes should elapse between eclipse-exit and retrofire. Graphical analyses by Christy[18] and Clark[19] show that the 31 revolutions repeating pattern of ground tracks employed for the Salyuts 6 and 7 lead to landing "windows" at intervals of approximately 2 months. Moreover, the duration of these windows varies from only 7 to 10 days depending on the time of year. These windows, in turn, impose constraints on mission durations. The 8-day Intercosmos missions, for example, were launched immediately prior to the opening of a landing window so that, if the need to abort prematurely should arise, as with the Bulgarian mission, the constraints could be obeyed on the third day.[20] To date, Soyuz T spacecraft have also obeyed these constraints and have yet to demonstrate the capability to make normal landings at any time of the day or night. If this practice is followed for Berezovoi and Lebedev, then the next window opening around the end of the year would prolong their mission to something in excess of **230** days.[21] The constraints could be obeyed in an emergency at other times of the year by moving the recovery zone from the Kazakhstan region. Cosmonauts have been depicted training for recovery from landings in water should such landings prove to be necessary .22

Up to a few years ago, the orbital module remained attached to the command module until after retrofire.

'Phrase used in a question by the *Tass* correspondent at Cosmonauts' press conference in Moscow, Jan 24, 1969, reported in SU ' 2984 'C '4

'*Cosmos 186* launched Oct. 28, 1967 *Cosmos 188* launched Oct. 30 First orbit rendezvous and docking at 0920 Z, Oct *30*. Undecked at 1250 Z, 3 hr *30* min total time docked *Cosmos 212* launched Apr 14, 1968. *Cosmos 213* launched Apr. 15 First orbit rendezvous and docking at 1021 Z, Apr 15 Undecked at 1411 Z, 3 hr 50 min total time docked.

[10]*Soyuz* 4, Vladimir Shatalov, launched Jan. 14, 1969. *Soyuz 5*, Boris Volynov, Yeugeniy Khrunov, and Aleksey Yeliseyev, launched Jan 15: 18th orbit rendezvous and docking at *0820 Z*, Jan. 16, Undecked at 1255 Z; 4 hr 35 min total time docked

''Soyuz *1* with Vladimir Komarov crashed Apr 24, 1967.

[12]Soyuz 11 landed on June 29, 1971; its three crewmen, Georgiy Dobrovolskiy, Vladislav Volkov, and Viktor Patsayev, perished

[13]*Soyuz 40* landed May 22, 1981

"*Cosmos 1001* launched Apr 4, 1978, recovered after 11 days, *Cosmos 1074* launched Jan 31, 1979, recovered after 60 clays

[15]*Soyuz-*, launched Dec. 16, 1979.

[16]*Soyuz-T* 3, Leonid Kizim, Oleg Makarov, and Gennadiy Strekalov launched Nov 27, 1980

[17]*Soyuz-T* 5 landed Aug. 27, 1982

[18]R. D Christy, "Safety Practices for Soyuz Recoveries, *Spaceflight* 23, 1981, pp. 321-322,

[19]P S Clark "Soyuz Missions to Salyut Stat Ions, *Spaceflight 21. 1979*. pp *259-263*.

[20]*Soyuz 33*, Nikolay Rukavishnikov and Georgiy Ivanov, Apr. IO-12 1979

[21]*Soyuz-T* 7 landed in poor conditions at night, Dec 10, 1982, 211days 9 hr 5 min record duration

[22]*Spaceflight 20*, 1978, p 305 shows Aleksey Gubarev and Vladimir Remek practicing for Soyuz 28

Latterly, it has been jettisoned prior to retrofire.[23] The orbital module, filled with bulky, used equipment, burns in the atmosphere on reentry and provides a means for disposing of unwanted material as an alternative to the regular use of the airlocks. The unloaded Progress performs a similar function but is deorbited over the Pacific rather than being left to decay naturally. The crew capacity of the Soyuz T is limited to three by the use of the A-2 vehicle for its launch. This booster, using the same first stage as that used to launch the first Sputnik **25 years ago,** is the only Soviet booster to be man-rated to date. The larger D vehicle now appears to be totally reliable and could possibly be man-rated at some future date for launching spacecraft with larger crew complements, and some Western observers speculate that the mysterious dual payload launches at 51.6° inclination were reentry tests of reusable winged spacecraft .24 The Cosmos 1374 mission of summer **1982 has** been claimed to have been a reentry test of a scale model winged spacecraft, launched by the intermediate capacity C vehicle; the Royal Australian Air Force released pictures of the follow-on Cosmos 1445 spacecraft being recovered from the Indian Ocean. [25] Nevertheless it is not unreasonable to suppose that research and development work leading to a reusable manned spacecraft to service a permanently manned space station is in hand.

The unmanned Progress craft is something more than an interim measure to provide space-station crews with fresh supplies. The Soviets have mastered the technique for resupplying their Salyut stations with propellant and potable water, a feat unmatched in the Skylab missions and, as yet, unnecessary for the space Shuttle. Moreover, the residual propellant of the Progress engine has been used to maneuver the Soyuz-Salyut-Progress orbital complex in the manner of a primitive space tug.[26]

The altitudes selected for the Salyut missions below the Van Allen radiation belts[27] are not the most economical in terms of propellant usage, The relatively high air-drag, particularly in the case of the "military" Salyuts 3 and 5,[28] made great demands on stored propellants to maintain the orbit throughout the duration of the missions. Choice of a greater altitude to minimize propellant consumption exacts a penalty in terms of surface resolution for Earth observation programs. As space stations increase in physical size and complexity the drag problem will attain an even greater significance.

The small interior volume of the Salyut stations, which have an effective floor-area of 16 square meterszg in the Working compartment, must lead to cramped conditions, especially at times when the cosmonauts are joined by' visiting crews. **A** first step towards increasing the interior volume came with the docking of Cosmos **1267, a** "prototype space module, "[30] with Salyut 6. Although this docked complex was never manned, it was claimed[21] that future stations could be enlarged by docking with modules dedicated to different disciplines including crew rest and relaxation. The Cosmos l267 engine was used to maintain the Salyut 6 orbit[32] and eventually to deorbit the docked complex at the close of the joint mission .33 Cosmos 1267 and its preclecessor, Cosmos 929, were both reported to have returned part of their structure to Earth after a period of some 30 days.[34] Salyuts 3 and 5 also returned capsules during the unmanned phases of their missions, and thus an unmanned return capability already can be seen to exist .35

Another disadvantage of the current Salyut program is the lack of near-continuous communication with ground stations. For long periods in each orbit the crew is out of touch with ground control. In the initial stage of Soviet manned spaceflight this disadvantage was partially overcome by the use of shortwave frequencies for voice communication as well as the long-range housekeeping telemetry still in use today. Later, merchant ships were converted to provide communication links through Molniya satellites,[3b] and purpose-built vessels have since moderrized the space support fleet maintained by the U.S.S.R. Academy of Sciences .37

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[23]Orbital module of first Soyuz-T **discarded 25 March** 1980, **cataloged by RAE as** 79-103D **but as 77-97BR by** NORAD.

[24]*Cosmos 881-82,* Dec. 15 1976; Cosmos 997-998, Mar. 29, 1978; *Cosmos* 1101101, May 22, 1979; and T. Williams, "Soviet Re-entry Tests: A Winged Vehicle?" *Space flight 22, 1980,* pp. 213-214.

[25]*Aviation Week & Space Technology 116,* June 14, 1982, p. 18; and *Cosmos* 2374, June 3, 1982, (Pictures of the 1983 flight of Cosmos 1445, a similar spacecraft, **taken by the Royal Australian Air** Force have been published by the world's media,)

[26]'. . during the joint flight the engines of Progress 15 **had** been used to make two adjustments of the trajectory of the orbital complex, " (*Tass* in Russian for abroad, 1436 GMT, Oct. 14, 1982, reported in SU/7163/D/3.

[27]Explorer 1 discovered radiation belt at 950 km.

[28]*Salyut 3256-292* km, Salyut 5214-257 km.

[29]Yu Semenov and **L. Gorshkov,** " 'Salyut **6' Orbital** Station: Home, Laboratory, Vehicle, " *Nauka i Zhizn',* April 1981, pp. 43-53, 125, reproduced in JPRS 78779, Space #12, Aug. 19, 1981, p. 7.

[30]Cosmos 1267 docked with Salyut 6 at 0752 GMT, June 19, 1981. Moscow *Home Service,* 0930 GMT, June 19, 1981, reported in SU/6755/D/1.

[31]Interview with Konstantin Feoktistov, UPI, 1248 GMT, June 24, 1981; and interview with Konstantin Feoktistov, *Tass,* Russian for abroad, 0508 GMT, June 24, 1981, reported in SU/6770/D/1.

[32]Moscow *Home Service,* 1400 GMT, July 1, 1981, reported in SU /6770/D/l.

[33]*Tass,* Russian for abroad, 1057 GMT, July 29, 1982, reported in SU/ **7095/D/1.**

[34]**"Part of New Soviet Space** Station Deorbited **and Recovered, "** *Defense Daily,* May 29, 1981, p. 153, (Cosmos 1267 capsule returned May 24, 1981.)

[35]Salyut 3 returned capsule on Sept. 23, 1974. *Tass,* Russian for abroad, 1405 GMT, Sept. 26, 1974, reported in SU/4715/C/1 and Salyut 5 returned capsule on Feb. 26, 1977. *Tass* in Russian, 1502 GMT, Mar. 2, 1977, reported in SU, 5458/C/l.

[36]*Tass* in English, 0900 GMT, Oct. 18, 1969, reported in SU '3207 C 2,

[37]G. Bezborodov and A. M. Zhakov, "Suda Kosmicheskoy Sluzhby," *Izdatel'stvo "Sudostroyeniye,"* **(Leningrad: 1980), reproduced** in JPRS L 9862, Space FOUO 3/81, pp. 1-21.

Details of an Eastern Satellite Data Relay Network (ESDRN) lodged with the International Frequency Registration Board in 1981[38] show that the Soviet Union intends to operate a system employing frequencies in the Ku-band[39] similar to the American TDRSS for communicating with Salyut stations and other spacecraft in low-Earth orbit, commencing no sooner than December **1985.**

Following the end of the manned phase of the Salyut **6** mission in 1980, articles appeared in the daily and technical press detailing the achievements and outlining future needs.'" Isvestiya stressed that those achievements were not only in the great reliability and longevity in space of the onboard systems and equipment but also in the vast amount of experimental work aimed at finding solutions for fundamental scientific problems and practical requirements on Earth today. The requirements of 22 of the Ministries and Departments of the U.S.S.R. were considered.

More than 1,600 experiments were said to have been performed involving some **150** items, many of which were repeated at least once .[4]1 Of these, 60 were astrophysical, 200 on the production of materials of exceptionally high purity, and 900 in medicine and biology. Many of the latter were in cooperation with other countries as part of the Intercosmos program. The superpure materials ranged from the homogeneous alloys and semiconductor materials, produced in the Kristall, Splav, and Isparitel furnaces and ovens, " to vaccines produced by elect rophoresis.[43] Much time was devoted to the observation of the Earth from space. Some 13,000 photographs were obtained using the Kate-140 topographical and MKF-6M multispectral cameras. 44 As a result, a supply of freshwater was located in the Kyzyl-Kum desert and large-scale geological features coinciding with mineral deposits and possible oil-bearing regions were identified .45 It was stated that photographs of an area covering 1 million km^2 could be recorded on film in 10 minutes, equivalent to the result of several years' aerial photography." (Salyut 4 was reported to have returned photographs of 4.5 million km^2 of the U.S.S.R.)[47] 1n addition to radioastronomy, experiments with the KRT-10 in 1979,[48] astronomical observations of active areas of the Sun's surface and other X-ray sources were made and infrared radiation from the planets and stars was recorded using the cryogenically cooled 1.5-meter diameter BST-lM telescope .49 For these observations an orientation accuracy of a few arc seconds was maintained, [50] and some Western commentators have seen military implications related to the pointing of directed-energy weapons in this context .5' Undoubtedly, there is a large area in which military and scientific experimental programs overlap each other.

Experience has shown that it is possible for crews to work in space for long periods at a time so Iong as they follow a regular exercise regime[52] to counteract the effects of prolonged weightlessness. Equally important is sustaining the psychological well-being of the crew. T. this end consideration has been given to the interior decoration of the station .54 It was found that working to a normal Earth time schedule was beneficial both to the cosmonauts and the ground-support teams, Regular rest days at weekends are used for housekeeping and relaxation. The introduction of a two-way television link" enabling the cosmonauts to see their families whilst talking to them at the weekends was a great morale-booster as were the visits from short-term crews. However, the strain began to tell on the Salyut **7** cosmonauts who set the record of 211 days in space, and their working day was reduced from 16 to 12 hours.[5b]

And what of the future? Steps must be taken to overcome the disadvantages of the current program mentioned above. More efficient transport crafts are needed. A Soyuz can deliver only 50 kg of supplies in addition to its crew, and Progress is limited to 2,300 kg. " Although Progress transports delivered more than 20 tonnes of supplies to Salyut 6 in 12 visits, the greater part of the cargo comprised life-support system supplies and units, fuel and replacements for onboard systems .58 A *man* requires more than 10 kg of replacement life-support system elements every day,[59] and

"Special Section No **SPA-AA 343 1484 annexed to IFRB Circular No. 1484, Sept 1, 1981**

[39]10 **82, 1 I 32, 137** and **1352** GHz downlink; 14.62 and 1505 GHz uplink

[40]Feoktistov and Markov, idem , and Semenov and Gorshkov, idem and 'Looking to Orbit\ of the Future, *Isvestiya* July 14 1981, p 2, reproduced in JPRS 79319, Space # 13, Oct 28, 1981, pp 3-6, and K Feoktistov, "TO Future Orbits, " *Pravda*, June 9 1981, p 3, **reproduced** in **JPRS** 79319, **Space** # 13, Oct 28, 1981, pp 45-46

[41]Ibid p 46

[42]Semenov and Gorshkov, idem. **p** 9

[43]**Feoktlstov** and Markov idem p 11.

[44]Feoktistov, idem , p 4 6

[45] Feokt istov and Markov, idem , p 4

[46]A **P** Aleksandrov, *Isvestiya* July 14, 1981, p 2, reproduced in JPRS 79319, Space #13, Oct 28, 1981, p 3

[47]Feoktistov and Markov, idem , p 4

[48]N S Kardashev, A. I. Savin, M. B. Zakson, A G Sokolov, and K P Feoktistov, "The First Radio Telescope in Space, " *Zemlya i Vselennaya, No 4*, July-August IWO, pp 2-9, reproduced in JPRS 76578, Space #7, Oct 8, 1980, pp 1-15

[49]Feoktistov and Markov, idem. , p 6

[50]Feoktistov, idem , **p.** 46.

""Washington Round Up, " *Aviation Week & Space Technology 117, No 17*, Oct. 25, 1982, p. 15

[52] Semenov and Gorshkov, idem , P 15

[5]'N. Novikov, 'An Extended Expedition, " *Sovetskiy Voin* No 8, 1981, pp 29-29, reproduced in JPRS 78779 Space #12, Aug 19, 1981 pp 26-29

"Ibid , p. 8.

[55]Idem., p. 28,

[56]*Moscow World Service* in English, 1000 GMT, Oct 27, 1982, reported in SU 7182 D 1

[57]Novikov, idem , **p.** 27.

[58]Feoktistov and Markov, idem , p. 10.

[59]Ibid p 9

there is an obvious need to change over to a new life-support system operating on a closed cycle, thereby eliminating the need to deliver water and atmospheric purification supplies. (A water-regeneration system did not produce in excess of 500 liters of potable water on Salyut 6.[60] A reduction in the amount of fuel necessary for station orientation could be effected by the adoption of an electromechanical orientation system.[61] (Trials of this type of system were conducted on Salyut 3 and must be presumed to have been less than satisfactory since this principle has yet to be adopted operationally.)

The introduction of a new onboard computer system for Salyut 7 has relieved the crew of much routine work connected with the operation of the station.[62] This is markedly noticeable in communication sessions with ground control. On previous missions much time was spent in calling "Zaria," the ground control, in order to confirm that two-way contact had been established. Today, the computer switches on the transmitter when the stations rises above the radio horizon of the ground station, and the cosmonauts speak from wherever they chance to be in the station at the time. Feoktistov, commenting on the introduction of computer and microprocessor technology, has cautioned that enthusiasm for automation can lead to extraordinary complexity and, consequently, a reduction of equipment reliability.[63]

The elimination of the need to mothball the station between periods of occupancy by long-term crews would be a logical step in the steady evolution of Salyut operations. A further improvement would be the provision of facilities for receiving water and propellant from Progress transports at either of the two docking ports. This would eliminate the transportation and redocking which has hitherto been necessary to relocate the Soyuz at the forward docking port in order to accommodate a Progress at the aft port. Such redesign may also encompass provision of nonaxial docking ports although destruction of axial symmetry could introduce problems In maneuvering and altitude control.

In the distant future one might expect the Soviets to take steps to establish a permanent space station in geosynchronous orbit[64] for the collection of solar energy, its conversion to electrical energy, and transmission to Earth by microwaves, but these possibilities introduce difficulties several orders of magnitude greater than those solved to date.

[60] Feoktistov and Markov, idem., pp 10-11.
[61] Idem., p. 11.
[62] Moscow *Home Service,* 1800 C; MT, May 21, 1982, reported in SU/7034/D/2; and *Moscow Home Service, 0200* GMT, May 23, 1982, reported in SU / 7048/D /2; and *Isvestiya,* July 16, 1982, reported in SU/7122/D/3.

[63] Feoktistov and Markov, idem., p. 10.
[64] Idem., p. 11.