Section 7 - Crew Training

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7.1 Overview of Crew Training

Working Group 5 – crew exchange and training – was a small group that consisted of two people from the Russian side (A. Alexandrov, Y. Kargopolov) and the American side (Don Puddy, through mid 1995, C. Brown, mid 1995-Present, and T. Capps).

The objectives of the group were to determine the duties and responsibilities of cosmonauts and astronauts when completing flights on the Shuttle and Soyuz vehicles and the *Mir* station, the content of crew training in Russian and in the U.S., and to developing training schedules and programs.

The group maintained a fairly standard work process. Periodic meetings were usually held alternating in Russia and in the U.S. Between meetings contact was maintained through the use of teleconferences and faxes.

To widen the operational interaction on joint flight training issues, a Johnson Space Center (JSC) office (NASA) was created at the Gagarin Cosmonaut Training Center (GCTC) where an American representative permanently worked.

This position, which was called the "Director of Operation, Russia" (DOR) was filled by a representative from the astronaut corps. He took part daily in resolving issues related to cosmonaut and astronaut training for joint flights and implemented the agreements and resolutions of WG-5.

The Crew Exchange and Training Working Group also defined the agreements for the placement of emblems on crew flight clothing. The number and type of personal articles permitted for crew members during flights on different vehicles, the content and schedule for postflight activities, and also any other issues on crew exchange and training or crew-related issues that did not enter the area of responsibility of other working groups. During their period of work, the group developed and managed the following documents:

Crew Exchange and Training Working Group Documents

Table 7.1

5000	Duties and responsibilities of the *Mir*-18 astronaut.
5001	Duties and responsibilities of cosmonauts on the Shuttle during flight STS-71.
5002	Duties and responsibilities of the STS-71 astronauts on the *Mir*.
5003	*Mir*-18/Shuttle science.
5004	*Mir*-18 astronaut's training plan.
5005	STS-71 cosmonauts' training plan for Shuttle systems.
5006	STS-71 astronauts' training plan on *Mir*.
5007	Critical Shuttle terminology.
5008	Critical *Mir* terminology.
5010	Cosmonaut's science training plan under the STS-71 flight program.
5011	Topics of symbolic activity and crew personal topics during flight STS-71.
5012	Crew members' personal and service souvenirs of the Phase 1 joint space program.

Table 7.1 Cont.

5013	Topics of psychological support for the *Mir*/NASA crews of the *Mir* complex. Packages and personal items.
5025	Dictionary (English-Russian) of U.S./Russia space programs.
5026	Dictionary (Russian-English) of U.S./Russia space programs.
5030	Crew emergency evacuation system.
5031	Habitable compartments hardware.
5032	Shuttle EVA systems.
5034	*Mir* EVA systems.
5035	*Mir* construction and systems for Shuttle crew members.
5101	Duties and responsibilities of *Mir* station crew members on the Shuttle.
5102	Duties and responsibilities of Shuttle astronauts on the *Mir* station.
5105	*Mir* station crew member training plan for Shuttle systems (mated configuration).
5106	Shuttle crew member training plan for the *Mir* station (mated configuration).
5200	Duties and responsibilities of astronaut crew members of long-duration *Mir* missions.
5201	Astronauts' training program for extended flights on *Mir*.
5203	Cosmonaut duties and responsibilities on Shuttle STS-84 (December 1996).
5204	Training plan for cosmonaut completing flight on Shuttle STS-84 (December 1996).
5205	Cosmonaut duties and responsibilities on Shuttle STS-86 (May 1997).
5206	Training plan for cosmonaut completing flight on Shuttle STS-86 (May 1997).
5207	Cosmonaut duties and responsibilities on Shuttle STS-89 (September 1997).
5208	Training plan for cosmonaut completing flight on Shuttle STS-89 (September 1997).
5209	Cosmonaut duties and responsibilities on Shuttle STS-91 (January 1998).
5210	Training plan for cosmonaut for flight on Shuttle STS-91 (January 1998).

When necessary the working group made the appropriate changes and additions to these documents.

Working Group 6 was responsible for the content of the U.S. science training.

The work of Russian-American crews on board the *Mir* began with the *Mir*-18 mission that included the participation of astronaut-researcher Norman Thagard, the first NASA astronaut to carry out a long-duration flight for the Shuttle-*Mir* program. Norman Thagard was launched on the Soyuz TM transport vehicle on 14 March 1995 and worked on the station as an astronaut-researcher for 115 days. STS-71 transported the *Mir* 19 cosmonauts to *Mir* and returned the *Mir* 18 crew to the Earth during July 1995.

The docking of Shuttle STS-76 on 24 March 1996 was the beginning of the continuous presence and operation on the *Mir* station of NASA astronauts as part of the NASA-*Mir* program.

NASA astronaut Shannon Lucid, operating under the auspices of the NASA-*Mir*-2 program, was transported to the *Mir* station approximately one month after the Russian crew of *Mir*-21 began operation on the station. Subsequently, five more missions were executed (NASA-3, NASA-4, NASA-5, NASA-6, and NASA-7). During that time, for the execution of American-Russian transport operations seven Shuttle dockings were performed with the *Mir*. The program entailing the continuous presence of NASA astronauts on the *Mir* station was completed on 8 June 1998 after the undocking of the *Mir* station and Shuttle STS-91.

The unique nature of astronaut training for the NASA-*Mir* program consisted of astronaut shift rotations on board the *Mir* that were executed using the Shuttle while the crews of the primary missions were operating on it and the rotation schedule of these crews differed from that of the astronauts. Thus, each NASA astronaut had to operate as a member of several primary missions. With such a rotation system it was not always possible to ensure the training of astronauts as part of all of the crews with which they would be working on board the *Mir*. The system of astronaut rotation on the *Mir* is presented in table 7.2.

In all, over the period of operations for the Shuttle-*Mir* and NASA-*Mir* programs, 9 NASA astronauts were trained at the GCTC for the performance of long-duration spaceflight on the *Mir* station (7 of them executed spaceflights). Four astronauts underwent training in EVAs (3 of them performed EVA operations in flight).

Two training sessions each were performed at JSC and at the GCTC for the performance of the joint Russian-American science program using the primary and back-up crews of *Mir*-18, *Mir*-21, *Mir*-22, *Mir*-23, *Mir*-24, and *Mir*-25.

Within the framework of the NASA-*Mir* program 5 Russian cosmonauts (Krikalev, Titov, Kondakova, Sharipov, and Ryumin) underwent training at JSC for Shuttle flights as part of American crews, and executed space flights (twice for Titov). The corresponding Shuttle flights are STS-60 -63, -84, -86, -89, and -91.

Nine Shuttle crews (STS-71, -74, -76, -79, -81, -84, -86, -89, and -91) underwent a week of training in Russia for the *Mir* station for joint activity with Russian crews. The Russian primary and backup crews of *Mir*-20-25 underwent training at JSC for one week for the Shuttle and joint activity with STS crews (6 times in all).

Training of Russian-American *Mir* crews and Shuttle crews concerning *Mir* systems and Russian cosmonauts concerning Shuttle systems was carried out in accordance with the approved training programs and on the basis of the experience of training for joint flights for the Shuttle-*Mir* program. The total duration of the training of each of the astronauts was to have been 14 months. However, due to changes in the program and delays in the assignment of astronauts, this condition was not fulfilled for some of the American astronauts.

7.2 Training of Astronauts in Russia

NASA astronauts were trained at the GCTC to perform spaceflight on the *Mir* scientific research complex as flight engineers-2. This was done in two phases:

- as part of a group of astronauts;
- as part of a crew.

Table 7.3 presents generalized data concerning the scopes and dates of NASA astronaut training with allowance for backup.

7.2.1 Training as Part of a Group (Stage 1)

Training as part of a group entailed:

- technical training for the Soyuz TM transport vehicle;
- practical classes and training sessions on Soyuz TM simulators and stands;
- technical training for the *Mir* orbital complex;
- practical classes and training sessions on station and module simulators;
- medical/biological training, including flights in “weightlessness,” medical examination, and physical training;
- survival training under extreme conditions;
- independent training;
- Russian language study.

The organization, scope, and content of training, and its technical and methodological support enabled the following tasks to be accomplished:

- acquisition of fundamental knowledge concerning the principles of design, layout, and operation of the onboard systems of the spacecraft comprising the *Mir* orbital complex;
- development of fundamental skills for the performance of typical operations for the control and servicing of onboard systems;
- learning of concepts, terms, and abbreviations used in Russian space technology (including the flight data files of the *Mir* complex);
- learning of Russian language.

Data concerning the scope of astronaut group training are cited in table 7.4.

As a result of the successful performance of these tasks the main goal was achieved: The required level of professional astronaut training needed to continue training as part of a crew was provided.

In the postflight reports of the first astronauts who executed spaceflight in the NASA-*Mir* program, it was noted that during the process of the subsequent cooperation of Russia and the U.S. in the field of manned spaceflight under the NASA-*Mir* program, the effectiveness of the training of American astronauts and its results can be significantly increased if the following measures are implemented:

- It is advisable to update the Russian program of theoretical training (first of all, in the area of fundamental knowledge) with allowance for the level of professional training of the NASA astronauts and their experience in the execution of spaceflights;
- Technical training needs to be started when the NASA astronauts attain a sufficient level of Russian language learning, especially for its everyday usage. A more intensive study of the Russian language and its technical applications should be continued during the process of technical training;
- An optimal combination of theoretical knowledge and the independent work of NASA astronauts should be provided during the initial stage of training — when the level of Russian language study is not high enough. The duration of the theoretical classes should not exceed four hours (it is advisable that the rest of the workday be planned for independent work by the astronauts, for consultations, and physical training). During this stage it is especially important to have all the methodological materials in two languages: Russian and English.

7.2.2 Training as Part of a Crew (Stage 2)

Training as part of a crew entailed:

- technical training for the Soyuz TM transport vehicle;
- practical classes and training sessions on Soyuz TM simulators and system mockups;
- technical training for the *Mir* orbital complex, practical classes and training sessions on station and module simulators;
- medical/biological training;
- training for the NASA-*Mir* scientific research program;
- training for the EVA program;
- preflight training as part of crew;
- independent training;
- Russian language study.

Data concerning the scope of astronaut training as part of a crew are cited in table 7.5.

Joint training with crew members made it possible for the astronauts to successfully perform training program tasks as part of a crew — to develop skills at the necessary level to perform the following types of activity within the scope of functions conferred on a flight engineer-2:

- assure crew safety, including the execution of operations for emergency descent on the Soyuz TM transport vehicle;
- support the reliable operation of the onboard systems and equipment of the complex;
- perform work station organization;
- exchange information with the NASA consultative group at Mission Control Center (MCC)-Houston;
- perform research and experiments;
- perform household procedures and physical exercises using onboard facilities.

In the opinion of the Russian crew members and American astronauts that worked under the NASA-*Mir* program, during the phase of training as part of Russian-American crews, greater attention needed to be given to matters of the psychological compatibility of crew members. For this, a longer training period should be carried out for each crew with which an astronaut will be working on board the *Mir*. Joint training sessions for survival under extreme conditions would also contribute to this.

The backup system that was initially developed and approved by the sides stipulated the execution of a flight by an astronaut mainly as part of a crew with which he underwent backup training, which ensured a longer joint training of cosmonauts and astronauts. The cancellation of Scott Parazynski's training and the subsequent alteration of the astronaut team and the dates of their arrival at the GCTC did not allow the backup system to be fulfilled.

The results of the integrated examination training session determined that the main goal had been attained: the level of professional crew training proved sufficient for it to be cleared for spaceflight and for the performance of the science program on board the *Mir*.

Astronaut Rotation on the *Mir*

Table 7.2

Mission/ Astronaut	Date work began on *Mir*	Date work completed on *Mir*	Period of operation as part of Russian-American crew	Total duration of operation on *Mir*	Total duration of EVA
NASA-1 Norman Thagard	⇑ Soyuz TM-20 3/16/95	⇓STS-71 7/7/95	3/14/95-7/7/95 *Mir*-18 (Dezhurov, Strekalov)	115 days	no
NASA-2 Shannon Lucid	⇑STS-76 3/24/96	⇓STS-79 9/26/96	3/24/96-8/2/96 *Mir*-21 (Onufrienko, Usachev) 9/2/96-9/26/96 *Mir*-22 (Korzun, Kaleri)	188 days	no
NASA-3 John Blaha	⇑STS-79 9/19/96	⇓STS-81 1/20/97	9/19/96-1/20/97, *Mir*-22 (Korzun, Kaleri)	122 days	no
NASA-4 Jerry Linenger	⇑STS-81 1/15/97	⇓STS-84 5/21/97	1/15/97-3/1/97 *Mir*-22 (Korzun, Kaleri) 3/2/97-5/21/97 *Mir*-23 (Tsibliev, Lazutkin)	126 days	4 hours 58 minutes
NASA-5 Michael Foale	⇑STS-84 5/17/97	⇓STS-86 10/3/97	5/17/97-8/14/97 *Mir*-23 (Tsibliev, Lazutkin) 8/14/97-10/3/97 (Solovyev, Vinogradov)	139 days	6 hours
NASA-6 David Wolf	⇑STS-86 9/30/97	⇓STS-89 1/29/98	9/30/97-1/29/98, *Mir*-24 (Solovyev, Vinogradov)	122 days	6 hours 47 minutes
NASA-7 Andrew Thomas	⇑STS-89 1/24/98	⇓STS-91 6/8/98	1/24/98-2/19/98, *Mir*-24 (Solovyev, Vinogradov) 2/19/98-6/8/98 *Mir*-25 (Musabayev, Budarin)	135 days	no

Scope and Dates of Training

Table 7.3

Mission Astronaut (backup)	**Dates of beginning/end of operation on *Mir***	**Training with Russian crew (backups)**	**Dates of astronaut training (in group, as part of crew)**	**Total hours of training in group, crew (as primary, backup)**	**Total training hours of astronauts**
NASA-1 Norman Thagard (Bonnie Dunbar)	⇑Soyuz 20 3/16/95 ⇓STS-71 7/7/95 (115 days)	*Mir*-18 Dezhurov, Strekalov	3/1/94-10/7/94 10/10/94-2/21/95	883, 845	1728
NASA-2 Shannon Lucid (John Blaha)	⇑STS-76 3/24/96 ⇓STS-79 9/25/96 (188 days)	*Mir*-21 Onufrienko, Usachev (Tsibliev, Lazutkin)	1/3/95-6/24/95 6/26/95-2/26/96	795, 1127	1922
NASA-3 John Blaha (Jerry Linenger)	⇑STS-79 9/19/96 ⇓STS-81 1/20/97 (122 days)	*Mir*-22 Korzun, Kaleri (Manakov, Vinogradov)	2/23/96-7/1/96 5/29/95-7/19/96 (4/14 months)	795, 503 \ 959	2257
NASA-4 Jerry Linenger (Michael Foale)	⇑STS-81 1/15/97 ⇓STS-84 5/21/97 (126 days)	*Mir*-23 Tsibliev, Lazutkin (Musabayev, Budarin)	9/23/96-12/6/96 \ 11/29/95-12/20/96 (2.5 \ 13 months)	765, 605 \ 1054	2424
NASA-5 Michael Foale (James Voss)	⇑STS-84 5/17/97 ⇓STS-86 10/3/97 (139 days)	*Mir*-24 Solovyev, Vinogradov (Padalka, Avdeyev)	1/13/97-4/9/97 \ 4/3/96-4/30/97 (3 \ 14 months)	899, 408 \ 840	2147
NASA-6 David Wolf (Wendy Lawrence)	⇑STS-86 9/30/97 ⇓STS-89 1/29/98 (122 days)		9/2/96-8/27/97 \ 9/2/96- 8/12/97 (12 \ 11.5 months)	1081, 614	1695
NASA-7 Andrew Thomas (James Voss)	⇑STS-89 1/21/98 ⇓STS-91 6/8/98 (135 days)	*Mir*-25 Musabayev, Budarin (Afanasyev, Treshchev)	1/16/97-12/5/97 \ 9/8/97-12/5/97 (10.5 \ 3 months)	982, 553	1535

Scope of Training as Part of a Group for U.S. Astronauts

Table 7.4

Mission/ Astronaut (backup)	Training for Soyuz TM TV		Training for *Mir*		Medical/ biological training	EVA training	Independent training	Russian lang.	Total
	Technical training (hours)	Training on simulators (hours)	Technical training (hours)	Training on simulators (hours)	(hours)	(hours)	(hours)	(hours)	(hours)
NASA-1 Norman Thagard (Bonnie Dunbar)	134	173	120	50	170	--	86	150	883
NASA-2 Shannon Lucid (John Blaha)	20	50	114	60	122	--	161	268	795
NASA-3 John Blaha (Jerry Linenger)	20	50	114	60	122	--	161	268	795
NASA-4 Jerry Linenger (Michael Foale)	26	21	114	34	132	--	152	286	765
NASA-5 Michael Foale (James Voss)	50	23	108	40	156	93	154	275	899
NASA-6 David Wolf (Wendy Lawrence)	77	91	54	22	153	--	172	349	918
NASA-7 Andrew Thomas (James Voss)	49	165	60	13	180	32	147	336	982

Scope of Training as Part of a Crew for U.S. Astronauts

Table 7.5

Mission	**Training for Soyuz TM TV**		**Training for *Mir***		**Medical/ biological training**	**EVA training (prim./ backup)**	**Training for science program (prim./ backup)**	**Preflight training (prim./ backup)**	**Indep. Training (prim./ backup)**	**Russian lang. (prim./ backup)**	**Total (prim./ backup)**
Astronaut (backup)	Technical training (prim./ backup) (hours)	Training on simulators (prim./ backup) (hours)	Technical training (prim./ backup) (hours)	Training on simulators (prim./ backup) (hours)	(prim./ backup) (hours)	(hours)	(hours)	(hours)	(hours)	(hours)	(hours)
NASA-1 Norman Thagard (Bonnie Dunbar)	35	90	128	68	94	4	311	80	11	24	845
NASA-2 Shannon Lucid (John Blaha)	80/ -	130/ -	141/ -	142/ -	180/ -	--	266/ -	24/ -	76/ -	88/ -	1127/ -
NASA-3 John Blaha (Jerry Linenger)	6/79	29/172	16/139	81/141	100/147	--	239/209	--	--	32/72	503/959
NASA-4 Jerry Linenger (Michael Foale)	13/49	20/206	26/84	81/97	60/153	46/75	303/230	--	--	56/160	605/1054
NASA-5 Michael Foale (James Voss)	14/18	22/50	22/102	46/78	62/110	4/57	142/339	--	41/48	55/38	408/840

Scope of Training as Part of a Crew for U.S. Astronauts

Table 7.5 Cont.

Mission	**Training for Soyuz TM TV**		**Training for *Mir***		**Medical/ biological training**	**EVA training (prim./ backup)**	**Training for science program (prim./ backup)**	**Preflight training (prim./ backup)**	**Indep. training (prim./ backup)**	**Russian lang. (prim./ backup)**	**Total (prim./ backup)**
NASA-6 David Wolf (Wendy Lawrence)	10/ -	82/ -	126/ -	100/ -	71/ -	96/ -	121/ -	--	--	8/ -	614/ -
NASA-7 Andrew Thomas (James Voss)	18	58	78	77	144	64	104	--	6	4	553

Note: M. Foale additional group science training - 137 hrs,
A. Thomas additional group science training - 93 hrs.

7.3 *Mir* Station Systems and Soyuz TM Training

The goal of the technical training of astronauts was to provide the level of knowledge and primary skills for the operation of the onboard systems of the Soyuz TM transport vehicle and the *Mir* station necessary for the performance of training sessions on simulators within the limits of their functional duties.

During the technical training of astronauts for the NASA-*Mir* program, particular attention was given to the onboard systems that have a substantial impact on crew safety. These include the life support systems complex (КСОЖ), the thermal mode control system (СОТР), and the motion control system (СУД). Theoretical and practical courses were carried out for these as well as other onboard systems.

Special features of training for the life support systems complex (КСОЖ)

Theoretical and practical courses were performed concerning the control and servicing of the *Mir* life support systems complex (КСОЖ) within the full scope of the functions of the flight engineer-2.

Special features of training for the thermal mode control system (СОТР)

Practical courses were performed to develop the astronauts' skills for the execution of vital operations:

- filling the СОТР loops with gas and coolant;
- replacing the coolant in the СОТР loops;
- separating the interior СОТР loops;
- finding and eliminating leaks in pipelines, etc.;
- developing skills to prevent loss of condensate and for its collection;
- developing skills for setting up ventilation of the complex and individual modules depending on the actual temperature/humidity conditions;
- developing skills for the operation and servicing of the main condensate discharge lines: operation with БКВ-3 (air conditioning unit);
- operating with ХСА БО ТК;
- operating with БОВа;
- developing skills for monitoring and control of the СОТР taking into consideration its actual state

Special features of training for the motion control system (СУД)

- performance of theoretical and practical courses to study identified off-nominal situations in connection with the extended operating time of individual СУД units;
- performance of practical courses at RSC Energia (RSC-E) control and test station for the servicing and repair of the СУД to develop skills for replacing units and parts and switching electrical cables.

Special features of technical training for the Soyuz TM transport vehicle

The technical training of astronauts for the transport vehicle was performed taking into consideration their function as cosmonaut/researcher during the performance of operations for an ahead-of-schedule or emergency descent from orbit. Astronauts were given a general idea of the transport vehicle's onboard systems, the plan for the execution of descent from orbit, as well as practical skills for self-help using the КСОЖ, conducting radio communications with MCC, evacuating the spacecraft after landing (splashdown), and survival.

7.4 Training in the Soyuz TM Integrated Simulator

Astronaut Norman Thagard was inserted into orbit on board the Soyuz TM transport vehicle. For this reason, practical courses and training sessions were carried out with him as part of the *Mir*-18 crew for the performance of all the flight program phases within the scope of the functional duties of the cosmonaut/researcher.

Subsequently, NASA astronauts during the implementation of the NASA-*Mir* program were transported and returned to Earth on the Shuttle. For this reason, NASA astronauts underwent training for the transport vehicle flight program only for the execution of descent from orbit (including emergency descent) in the event of the emergency evacuation of the orbital station and were seated in the seat of the cosmonaut/researcher.

On the basis of these baseline data a typical training program was developed for NASA astronauts as crewmembers on the integrated simulator of the transport vehicle and for actions to take in off-nominal and emergency situations in order to perform the assigned tasks and assure flight safety.

The typical program provided for the fulfillment of the following requirements for the training of NASA astronauts for the Soyuz TM transport vehicle:

- An astronaut must be familiar with the transport vehicle design and layout and onboard systems;
- An astronaut must know how to execute an emergency evacuation of the *Mir* station as part of the crew, the actions to take to prepare for emergency descent in the event of fire, depressurization, specific flight data files, and have the following practical skills:
    - open/close СА-БО hatch, check to see that it is airtight;
    - operate personal protective gear (Sokol space suit, etc.);
    - operate the following valves: ЭПК-РД, ЭПК-ПСА, РПВ-2, 3В valve: (СА condensate - БО condensate);
    - output commands from the right control panel (КСП).
- An astronaut must know how to use the telephone communications system (to conduct radio communications), the water supply system, and the wastewater system.

The typical training program entailed the following:

1. Program for the performance of practical courses with NASA astronauts on the ТДК-7СТ(2) integrated simulator.
2. Program for the training of NASA astronauts as part of a crew on the simulator for the integrated control of the transport vehicle during descent from orbit, for actions to take in off-nominal situations and for flight safety assurance ТДК-7СТ(2).
3. Program for the study of flight data file sections, of the flight program, and transport vehicle ballistics.

Summary of the Typical Training Program:

Table 7.6

Name of exercises	**Number of exercises/ number of hours**
Training for practical exercises with NASA astronauts	3 / 6
Practical exercises with NASA astronauts on integrated simulator	3 / 12
Training for training sessions as part of crew for integrated control of transport vehicle during descent from orbit	5 / 10
Training sessions as part of crew for integrated control of transport vehicle during descent from orbit	5 / 20
Study of flight data files, flight program, and transport vehicle ballistics (in class)	10 / 20
TOTAL:	68 hours

The NASA astronauts' readiness is verified by a board during the performance of a test training session on the transport vehicle integrated simulator for the performance of a descent as part of a crew and during a test concerning the flight program and transport vehicle ballistics within the framework of the typical training program.

Upon completion of the NASA astronauts' training program concerning the Soyuz TM transport vehicle for the NASA-*Mir* program, the following conclusions can be made on the basis of its analysis:

- On the whole, the scope and content of the exercises enables a NASA astronaut to be trained to execute, if necessary, a descent from orbit as part of the crew on the Soyuz TM transport vehicle in the seat of the cosmonaut/researcher.
- The replacement of Russian cosmonauts on the *Mir* station did not coincide with the replacement of NASA astronauts. Therefore, the American astronaut often flew with two different crews. But during training it was not always possible to conduct training sessions for descent with both one crew and with the other because their training times did not coincide.
- The effective and qualitative training of NASA astronauts during the initial stage was hampered by the poor knowledge that some of them had of the Russian language.

The given experience of NASA astronaut training for the NASA-*Mir* program needs to be taken into consideration during subsequent training for ISS:

1. It is possible to provide only minimum training if the duties on Soyuz are limited to those of a passenger.
2. It is best to perform NASA astronaut training sessions for descent from orbit on the Soyuz TM transport vehicle with all crews with which the possibility exists for executing a descent.
3. Before the beginning of Soyuz TM transport vehicle training the NASA astronaut should be proficient in the Russian language.

7.5 Training of Astronauts on *Mir* Orbital Complex Simulators and System Mockups

Russian-American crews were trained on *Mir* simulators and system mockups using the forms and methods used to train prior *Mir* crews. Training of a third crew member, the U.S. astronaut, as flight engineer-2, was the main difference in crew training in the *Mir*-NASA program.

The need to train an astronaut in the scope of flight engineer-2 duties arose as a result of analysis of participation in the operation of onboard systems and in the science program on board the *Mir* by Norm Thagard, as part of *Mir*-18 in the *Mir*-Shuttle program.

Training of NASA astronauts on *Mir* simulators and system mockups was conducted on the basis of the "Standard NASA Astronaut Training Program" No. E/5201, "Functions and Responsibilities of Astronauts and *Mir* Crew Members on Long-Term Missions," No. WG-5/NASA/GCTC/RSCE/5200, and science program Integrated Payload Requirements Document IPRD.

The NASA astronaut-training program called for individual practical classes (without participation of the entire crew) with astronauts on *Mir* simulators to develop the skills of operating the main onboard systems within the limits of flight engineer-2 functional duties. The purpose of these classes was to ensure a level of astronaut proficiency sufficient for training sessions as part of a crew.

The purpose of NASA astronaut training as part of a crew was to ensure *Mir* crew readiness to accomplish the entire mission on board the station and to take action in emergency and off-nominal situations. At this stage, in accordance with the scenario devised by the instructor, the crew as a single team would practice the basic elements of the mission program, including operation of several onboard systems and science hardware simultaneously, still-camera and video filming inside the *Mir* simulator, and conduct of radio and television communications with a simulated MCC.

Crew training on work organization on board the *Mir*, which in a number of cases causes problem situations associated with rescheduling of tasks and refreshment (acquisition) of the necessary knowledge and skills with onboard systems and science hardware even during execution of integrated modes (redocking, EVA preparation and conduct, transport-cargo vehicle remote operator mode and so forth) was the task of training sessions in integrated control of *Mir* onboard systems and science hardware.

In the process of crew training on *Mir* simulators, the required work style was developed, i.e. the totality of knowledge and skill necessary to perform the tasks of the mission program, as well as the ability to find optimal solutions in planning and organizing work on the *Mir*.

Additionally, much attention was paid in *Mir* crew training to questions of safety assurance, in particular to emergency evacuation of the complex in the event of emergency situations associated with depressurization or fire.

The NASA astronaut standard training program on the *Mir* simulators is shown below. Besides the practical classes and training sessions on the simulators, it also includes classroom sessions on flight data files (playing out of various flight situations from the flight data files), classes on ascertaining changes in *Mir* technical status, study of MCC functioning, and classes on the mission program.

Practical Classes and Classes on the Flight Data Files, *Mir* Technical Status, Structure and Functioning of GOGU Groups, and Mission Program

Table 7.7

№	Code	Class topic	Hours	Location	Notes
1	ПЗ-1	Developing practical skills in operating the СУБК and УИВК consoles	2	“Дон-17КС	Conducted with crew
2	ПЗ-2	Developing practical skills in operating the СУД and ОДУ onboard systems	2	“Дон-17КС	Conducted with crew
3	ПП-1	Technical status of *Mir* onboard systems and science hardware	2	class-room MCC	
4	ПП-2	Flight data files	2	class-room	Conducted with crew in preparation for session
5	ПП-3	Analysis of *Mir* mission progress	2	class, GCTC	
6	ПП-4	*Mir*-Shuttle joint procedures	2	class-room, GCTC	Jointly with STS crew
7	ПП-5	Mission program consultation	2	MCC	
		Total scheduled:	14		

Integrated Training Sessions

Table 7.8

№	Code	Class topic	Hours	Location	Notes
1	Тр-1	ПДС operation, experiments	6 (2+4)	“Дон-17КС	Only ПДС operation
2	Тр-2	ПДС operation, experiments	6 (2+4)	“Дон-17КС	Only ПДС operation
3	Тр-3	ПДС operation, experiments	6 (2+4)	“Дон-17КС	
4	Тр-4	ПДС operation, experiments, fire	6 (2+4)	“Дон-17КС+Т ДК-7СГ	as part of *Mir* No. – crew
5	Тр-5	СП-ЭО depressurization	6 (2+4)	“Дон-17КС”	
6	Тр-6	СП-ЭО depressurization	2	“ЭУ-734”	as part of *Mir* No. – crew
7	ТПС	standard flight days	10 (2+8)	“Дон-17КС”	as part of *Mir* No. – crew
8	ЭКТ	standard flight days	10 (2+8)	“Дон-17КС”	as part of *Mir* No. – crew
		Total scheduled:	52		

A board tests astronaut readiness during an examination session on the *Mir* integrated simulator (“Дон-17КС”) upon execution of the standard flight day program and test on the mission program.

7.6 Conclusions and Proposals for the Overall Astronaut Training Program

1. Overall the scope and content of the classes made it possible to train the NASA astronaut as a flight engineer-2 in the *Mir* crew with the functions defined by document No. 5200.

2. Because the replacement of Russian cosmonauts on the *Mir* did not coincide with the replacement of NASA astronauts, during training it was not always possible to hold joint training sessions of the American astronaut with all the crews with whom he/she would fly in space. The result was that in some flights the crew commander, without knowing the actual proficiency level of the astronaut, did not always trust the astronaut to perform individual flight engineer-2 operations, even when the latter was adequately trained to do so.

3. During ISS crew training, joint training of all members of a specific ISS crew should be conducted as frequently as possible, especially in the crew training stage. This will improve the effectiveness of work on board the complex and help to resolve the problem of language training in dealings between crew members and with ground control personnel, gradually reducing the use of interpreters in the training process.

4. To train ISS crews it is necessary to maximally utilize already-developed forms and methods of training for the *Mir* complex.

5. In order to improve the training of ISS crews and improve the effectiveness of their work on board the station, it would be helpful to analyze the actions of ISS crews in the course of spaceflights and to use the results of analysis in training.

7.7 Training for Cosmonauts in the U.S.

The cosmonauts were trained to several levels based on their responsibilities: Full Mission Specialists, passenger only, visitors to the Shuttle during docked phase. Mission Specialist's duties varied but included the use of the Shuttle life-support systems and communications systems in nominal and selected off-nominal situations, payload activities, earth observations and photographic activities. For one mission, duties included use of the Shuttle's remote manipulator system, and on another flight, the cosmonaut conducted an EVA. Training related to egress and emergency egress was also provided to ensure the safety of the cosmonaut under all conditions.

For the cosmonauts that were being transported to *Mir*, the training was reduced and was primarily designed to keep the cosmonauts safe. This training also provided a general familiarity of the Shuttle life and crew support systems. Table 7.9 provides data on training hours for both the mission specialists' roles and the safety training only.

For the *Mir* crews that only visited the Shuttle while docked, the training focused on a general familiarity of the Shuttle life and crew support systems and transfer operations between Shuttle and *Mir*. In general this training averaged about 36 hours.

A portion of the payload training for the cosmonauts also occurred in the U.S. during the sessions according to the joint schedule.

COSMONAUT SHUTTLE TRAINING*

Table 7.9

	INT ASC	INT ENT	INT ORBIT	ORBIT	ASCENT/ENTRY	ORBIT SYSTEMS	CREW SYSTEMS	EVA	PDRS	PAYLOADS	RNDZ/PROX OPS	SPACELAB	SPACEHAB	REFRESHER	NEW ASTRO		TOTAL
Krikalev (Titov)	1	15	75	53	63	9	70	24	151	70	70	0	16	128	80		**825**
Titov**	17	30	162	117	178	10	103	137	75	28	34	0	46	74	11		**1022**
Kondakova	1	7	50	60	21	8	70	13	0	6	22	0	27	21	57		**363**
Sharipov	1	7	50	0	4	0	50	0	0	2	0	0	3	16	7		**140**
Ryumin	0	7	40	36	8	8	74	0	0	0	15	0	12	23	43		**266**
Dezhurov	0	0	7	0	4	8	12	0	0	0	0	1	0	26	11		**69**
Strekalov	0	0	7	0	4	0	12	0	0	0	0	2	0	25	13		**63**

Table 7.9 Cont.

	INT ASC	INT ENT	INT ORBIT	ORBIT	ASCENT/ENTRY	ORBIT SYSTEMS	CREW SYSTEMS	EVA	PDRS	PAYLOADS	RNDZ/PROX OPS	SPACELAB	SPACEHAB	REFRESHER	NEW ASTRO		TOTAL
Onufriyenko	0	0	7	9	4	0	50	0	0	2	0	2	0	29	19		**122**
Usachev	0	0	0	9	0	0	30	0	0	2	0	2	0	0	5		**48**
Budarin	0	0	7	9	8	0	61	0	0	2	0	2	0	25	15		**129**
Solovyev	0	0	12	9	4	0	49	0	0	2	0	2	0	3	17		**98**

*Table reflects only formal training. Hours may vary due to different degrees of initial preparation (workbooks) while still in Russia.
**2 flights (STS 63, 86)

7.8 Crew Training for Execution of the Science Program

7.8.1 Crew Training for Execution of the Scientific Investigations and Experiments

Training of crews participating in the *Mir*-NASA international program was a most important component of the successfully executed scientific investigations and experiments (ННиЭ) program. The quality of space vehicle crew training, as spaceflight experience demonstrates, greatly depends on the organization of training, on the level of science hardware training model availability, and on the timeliness of flight data file and training-procedure systems development, as well as on the proficiency level of instructors and teachers.

The order, scope, and content of training of Russian cosmonauts and American astronauts in the scientific program were decided in accordance with the concurred Organizational Coordination Plan of the sides to implement the *Mir*-NASA scientific program (US/R-001), the Integrated Payload Requirements Document (IPRD), and proposals made by both sides for each specific mission.

The work procedures for organization of crew training to conduct American experiments on the *Mir* called for preparation of a preliminary training plan by the American side based on information about the planned experiments, with development of a final work plan by Russian experts to make sure that American demands were met. Based on the experience of joint work in the *Mir*-Shuttle program, the following order of training organization was developed: Training in a joint science program for the mission began with a 3-week session conducted at JSC by JSC instructors, including basic training in the experiments and familiarization with science hardware. Subsequently training was conducted at the GCTC by GCTC instructors with the participation of representatives of all interested organizations. Six months before launch there was a second 3-week session at JSC, basically including practical training and meetings with the experiment suppliers. The final training stage in the science program was conducted at the GCTC using a concurred set of flight data files.

The work procedure also required that the American side deliver all documentation on experimental methods, along with the hardware used in crew training within the framework of the joint science program, to RSC-E and the GCTC. During crew training the GCTC instructors were guided by the dimensional installation drawings, electrical diagrams, development requirements and technical descriptions for the development of hardware (documents 100 and 101), as well as by existing flight data files and training-methods documents.

Experience acquired in implementation of long-term crewed flights testifies that effective execution of the science program is possible only when the crew members are active participants in the scientific investigations and experiments.

This in turn is achieved when in the training process the cosmonauts are not restricted to forming the skills of experiment algorithm execution, but acquire some fundamental knowledge about the studied phenomenon in the necessary scope, and become acquainted with the design principles of the science hardware, its design, and functioning.

In this regard, based on the content of the *Mir*-NASA science program, the following crew tasks and functions were defined during training planning:

- participation in preparatory operations (circuit assembly etc.) and execution of experiments and investigations in accordance with onboard instructions and procedures;
- recording of experiment results (including with onboard recording systems and hardware);
- operation, maintenance and repair tasks with the science hardware;
- storage and delivery to the ground of materials with the results of science experiments and investigations.

GCTC experts participated in concurrence of the science program, development of the experimental procedures, and correction of the flight data files (from the results of flight data files used in crew training).

In the process of crew theoretical and practical training at the GCTC, available integrated *Mir* simulators and models, specialized science hardware stands (operator workplaces), and science hardware training models were used.

Crew members and instructors from both sides participated in training sessions. In the initial stage of training sessions, experiment suppliers, hardware curators and flight data file librarians from both sides participated. Crew readiness to perform the scientific investigations and experiments program was determined from the results of graded training sessions.

In order to enhance the quality of training of American astronauts and Russian cosmonauts for experiments in the *Mir*-NASA joint program, the following training hardware was transferred to the GCTC:

1. MIM – vibration-insulated platform;
2. TEM – MIM technological assessment;
3. QUELD II – electric oven;
4. PUP-A and PUB-B power distribution panels;
5. BTS – biotechnical system
6. CHAPAT – active telescope;
7. MGBx – glove box;
8. CFM (MGBx) – candle flame under microgravity conditions;
9. FFFT (MGBx) – flame propagation in gas stream;
10. ICE (MGBx) – interface surface investigation;
11. Dewar flask – protein crystallization;
12. EDLS – improved load sensors;
13. Canon A1 video camera with supplemental attachments;

14. Hasselblad camera;
15. TEPC – tissue-equivalent proportional counter;
16. SAMS – measurement of micro-accelerations in space;
17. SPSR – portable spectro-reflectometer for space conditions;
18. DCAM – diffusion-monitored protein crystallization;
19. BCAT – test of binary colloidal alloys

GCTC experts participated in acceptance tests (ПСИ) of science hardware simulators in order to study the submitted hardware, check conformity of flight and simulator models and develop experimental procedures.

During training, experts of GCTC and other organizations developed and utilized simulator models for science experiments, simulators of crew automated workplaces, and specialized databases, and a number of modern technologies were introduced.

In addition the GCTC performed a number of tasks to improve the training laboratory facilities in all scientific disciplines of the program. For these purposes:

1. They developed a laboratory for training in technical experiments (k. 106-3 and k.107-3). The laboratory includes:

- a working technical model of the Optizon-1 TX unit (the unit is used to perform an American experiment in liquid-phase sintering (LPS);
- maintenance systems;
- video monitoring system.

2. A laboratory was developed for training cosmonauts to perform biotechnical and biological experiments (k. 313-КМУ). The laboratory includes:

- the “Inkubator” science hardware training system;
- the “Oranzhereya-Svet” science hardware training system, which is installed and connected for training sessions to the “Kristall” module simulator;
- a hardware system support of cosmonaut training.

3. American hardware was installed, connected and stored for k.313-КМУ and k.225-2 (cosmonaut training laboratory for astrophysical and technical experiments) and k.208-2 (cosmonaut training laboratory for geophysical experiments).

4. Power distribution console PUP-B was connected to a 27 V power system in k.225-2.

5. Experimental procedures developed.

6. Experiment onboard instructions developed.

7. Repair and checkouts of technical model of Optizon-1 TX unit and its control system “Oniks” (malfunction occurred during joint development with American experts of a procedure for conducting the LPS experiment).

To study the procedures and acquire practical skills the following workplaces were developed in specialized laboratories:

1. To conduct the BTS experiment, study of possibility and effectiveness of growing various bio-objects under microgravity conditions.

Hardware:

BTS – biotechnical system;
PUP-A and PUP-B – power distribution consoles;
MIPS-2 – “Lepton” computer and controller.

2. To conduct the experiment with the Dewar flask hardware. Growth of protein monocrystals.

Hardware:

Dewar flask;
Canon A1 video camera with attachments.

3. To conduct an experiment with the “Inkubator” hardware system. Studying the influence of spaceflight on development of Japanese quail embryos.

Hardware:

“Inkubator” hardware system;
power supply.

4. On the “Kristall” module simulator, for an experiment with the “Oranzhereya-Svet” hardware system. Study of plant growth under microgravity conditions and determination of the influence of spaceflight on plant life cycles.

Hardware:

“Oranzhereya-Svet” hardware system;
camera;
MIPS-2 – “Lepton” computer and controller.

5. To conduct the MIM experiment. Provision of insulation from vibrations under microgravity conditions and creation of forced vibration.

Hardware:

MIM hardware:
MIPS-2 – “Lepton computer and controller;
PUP-A and PUB-B power distribution panels;
double container.

6. To conduct TEM experiment. Study of MIM hardware properties with regard to its capacity to ensure vibration insulation under microgravity conditions.

Hardware:

MIM hardware:
MIPS-2 – “Lepton computer and controller;
PUP-A and PUB-B power distribution panels;
double container.

7. To conduct the QUELD II experiment. Measurement of diffusion coefficients for certain bimetal systems under microgravity conditions.

Hardware:

QUELD II hardware;
MIM hardware:
MIPS-2 – “Lepton computer and controller;
PUP-A and PUB-B power distribution panels;
double container.

8. To conduct CFM experiment. Study of candle diffusion flame under microgravity conditions.

Hardware:

CFM hardware;
GBx hardware (glove box);
power supply.

9. To conduct FFFT experiment. Study of forced combustion propagation under microgravity conditions.

Hardware:
FFFT hardware;
GBx hardware (glove box);
power supply.

10. To conduct ICE experiment: Study of equilibrium forms which are assumed by a liquid surface under microgravity conditions. Study of "liquid-vapor" interface dynamics.

Hardware:

ICE hardware;
MGBx hardware (glove box);
power supply.

11. To conduct the EDLS experiment: Measurement of normal forces and torque's caused by crew members during nominal activity on board the *Mir*.

Hardware:

EDLS hardware;
MIPS-2 – "Lepton computer and controller;
PUP-A and PUB-B power distribution panels.

12. To conduct the LPS experiment: High-temperature liquid-phase sintering. Study of defect formation in sintering products: Analysis of wetting and formation of alloys.

Hardware:

"Optizon-1" hardware.
Servicing hardware set;
Canon A1 video camera with attachments.

7.8.2 Crew Training to Conduct the Medical Section of the Science Program

Successful accomplishment of medical and specifically biomedical experiments is not possible without careful study of working techniques and methods on the part of cosmonauts and astronauts in preparation for drawing blood, taking biological materials samples, and processing samples.

In the first stage cosmonauts and astronauts were trained in the method of drawing blood from a vein.

The first familiarization class was conducted by NASA in the U.S.

During the class the crew members were taught:

- how to find and isolate the major vessels;
- sterile treatment;
- procedures for drawing blood from a vein with a "Butterfly," a disposable needle with vacuum container;
- procedures for drawing blood from a vein with a catheter.

It should be noted that crew members were interested in the training material and actively participated in the practical development of blood-drawing skills.

Before the start of the practical classes, crew members were shown video materials which detailed the requirements of the World Health Organization for medical personnel regarding compliance with safety procedures with working with biological material.

For practical development of these techniques, cosmonauts and astronauts were asked to draw blood from 4 volunteers. This procedure allows the cosmonauts to quickly acquire the techniques for drawing blood from a vein.

As early as the fourth or fifth class, cosmonauts could independently draw blood from a vein. In the training process, instructors paid special attention to possible complications associated with blood-drawing procedures and the methods to prevent them.

In our opinion, the procedure of drawing blood with a catheter posed the greatest difficulty, but by the end of the first session all crew members could independently draw blood with a catheter.

Experienced medium-level medical personnel taught the classes. However it should be noted that at this stage the training was conducted in a “free” manner. American instructors did not strictly adhere to the flight data file, because at the start of the session it had not been fully developed.

At the GCTC the Russian instructors were faced with a simple but important task: to maintain the acquired skill of drawing blood from a vein. This goal was achieved through regular practical classes. At this stage the cosmonauts performed all procedures strictly per the flight data file. The basic drawback of the classes was the extremely low number of volunteers for blood drawing. As a rule associates of the Mission Medical Control Center responsible for this stage of training came to the class site in low numbers (one or two) or not at all. In most cases blood drawing was practiced on the GCTC physician-instructor and the NASA flight surgeon.

To enhance the quality of training of American astronauts and Russian cosmonauts, the following training hardware was delivered to the GCTC for performing experiments in the *Mir*-NASA joint program.

1. Blood drawing system;
2. Blood drawing system;
3. Blood drawing system;
4. Isotopic marker kit;
5. Antigen kit;
6. Blood sample analyzer;

7. Bar-code reader;
8. Pharmacokinetic system;
9. TEAK magnetic data recorder;
10. Blood pressure continuous monitoring system;
11. Cardiomonitor;
12. Cardiology kit;
13. Postural examination system;
14. Surface sampling kit;
15. Formaldehyde monitor;
16. Sorption air sampler;
17. Air sample container;
18. Lido hardware;
19. Laboratory hardware;
20. Laboratory accessories;
21. Postural equilibrium platform;
22. Bicycle ergometer;
23. Electric power system;
24. Gaze experiment hardware;
25. Locomotion experiment hardware;
26. Metabolism hardware
27. "Sleep" experiment hardware;
28. "Coordination" experiment hardware.

Laboratories were developed for training cosmonauts to conduct the medical program. These included simulator systems and workplaces for the following fields:

1. Evaluation of skeletal muscle work ("Rabota");
2. Morphological, gastrochemical and ultrastructural characteristics of skeletal muscles ("Myshtsa");
3. Gaze and head coordination ("Vzor");
4. Sensory perception characteristics ("Orientastiya")
5. Locomotive integration paths ("Orientastiya");
6. "Expectant pose";
7. Monitoring postural equilibrium ("Ravnovesiye");
8. Motion biomechanics during locomotion ("Lokomotsiya");
9. Surface microbiological analysis;
10. Water microbiological analysis;
11. Water chemical analysis;
12. Air chemical analysis;
13. Investigation of onboard radiation situation;
14. Homeostasis of fluid and electrolyte and its regulation ("Gomeostaz");
15. Calcium metabolism dynamics and bone tissue;
16. Kidney stone formation risk evaluation;
17. Protein metabolism ("Belok");
18. Energy utilization ("Energia");
19. Metabolic reaction to physical loads;
20. Erythrocyte metabolism ("Eritrotsit");
21. Erythrocyte mass and survival

22. Pharmacokinetic changes (“Farmakokinetika”);
23. Humoral immunity (“Gumor”);
24. Virus reaction (“Virus”);
25. Peripheral blood mononuclear cells;
26. Investigation of orthostatic stability using low-body negative pressure;
27. Investigation of orthostatic instability using ambulatory monitoring systems, check of baroreflector reflexes and Valsalda test (“Barorefleks”);
28. Determination of aerobic work capacity by means of dosed bicycle ergometry (“Stupenchata veloergometriya”);
29. Evaluation of temperature regulation during spaceflight (“Submaksimalnaya veloergometriya”)

7.8.3 Conclusions, Notes, and Suggestions

1. The adopted work procedures for organizing crew training, existing and specially developed technical and training methods resources, as well as the proficiency of GCTC instructors, made it possible to provide timely and high-quality training of Russian cosmonauts and American astronauts to perform a whole group of science experiments and investigations in the *Mir*-NASA program. At the same time the inadequate supply of science hardware training models at the GCTC should be noted. Instead of equipping them with science hardware simulators (on the “Spektr” and “Priroda” module simulators), it was necessary to supply modules only with face panels or photographs of the science hardware.

2. During planning sessions for science program training, it is necessary to provide for mandatory delivery of science hardware training samples to Russia. It is necessary to concur with the GCTC on the number and type of manufactured equipment intended for crew training. During crew training, classes were held in two 3- or 4-week sessions in the U.S. In the period of yearlong crew training, science hardware training models were practically non-existent at the GCTC. This disrupted the continuity of the training process and prevents classes during the integrated training sessions on the *Mir* simulator before the start of the mission. It must become our practice not to clear science hardware training models for crew training if it has not undergone acceptance testing, if it has no safety certificate, and if it has not been concurred on in documents with GCTC experts on the question of degree of simulation of science hardware flight sets.

3. Experience has been accumulated in planning, organization, and conduct of cosmonaut and astronaut training in joint international science programs. This training must be carried out in the form of training sessions, in the process of which direct interaction of cosmonauts, astronauts, and Russian experts with the experiment suppliers and hardware developers is possible. In the organizational context, it is necessary to reduce the time between the final crew training session for the science program and the launch of the crews (in the process of *Mir*-NASA program implementation, these intervals could reach 6 months).

4. In order to enhance the quality of cosmonaut and astronaut training for the scientific program of experiments and investigations, it is necessary to constantly adjust the training process with allowance for experiment results of prior missions. To do this, it is necessary to have movie materials and brief reports of the science experiment suppliers at the GCTC regarding the results of the experiments.

5. Untimely delivery to the GCTC of flight data files regulating the distribution of responsibilities, the content, procedure and sequence of execution of operations by crew members hampered the training. In virtually all training for the *Mir*-NASA program, classes were held per intermediate versions of the flight data files and unapproved experiment procedures.

6. For a number of experiments, no Russian cosmonaut participation was planned, with the result that no cosmonaut training was planned, even though they had to participate in practically all experiments or in science hardware repair tasks.

7.9 NASA Astronaut Training for the *Mir* EVA Program

In the process of the *Mir*-NASA science program, there were plans for three EVAs by the NASA astronauts in Russian-American *Mir* crews. Data on these EVAs are provided in table 7.10.

EVAs by NASA Astronauts in Russian American *Mir* Crews

Table 7.10

№	EVA Crew	Basic Tasks
1	V.V. Tsibliev J. Linenger (*Mir*-23)	Installation of optical properties monitors (OPM) on the DM. Installation of Benton dosimeter on the “Kvant-2” instrument science compartment (ПНО). Removal of PIE and MSRE science hardware from the docking ring (ШСО).
2	A.Ya. Solovyev M. Foale (*Mir*-24)	Inspection of depressurized “Spektr” module. Inspection of exterior cold radiator panel (НХР). Measurement of annular gap around the СБ-2 drive using a special gauge. Securing of stowage to handrails in “Miras” science hardware on science/cargo module (НГО). Rotation of ДСБ-4 and СБ-4 (solar arrays) Removal of Benton dosimeter science hardware from “Kvant-2” module instrument science compartment.
3	A.Ya. Solovyev D. Wolf (*Mir*-24)	Egress from science instrument compartment. Inspection of egress hatch. Measurement with SPSR instrument on exterior surface of pressurized instrumentation module 1 (ПГО-1). TV report on first EVA – D. Wolf. Closure of egress hatch on main and supplemental locks. Check of docking ring pressure integrity.

In the period from 6/10/96 to 6/28/96, 7 theoretical and practical classes (dry) and 5 sessions in the pool in “Orlan-DMA-GN” space suits were conducted on standard EVA operations with NASA astronauts J. Linenger and M. Foale.

Training of NASA astronauts J. Linenger and M. Foale in the EVA program was conducted in items “ORLAN-DMA-GN” numbers 19 and 20 and “ORLAN-M-GN numbers 7 and 8 on *Mir* mockups (DM, “Spektr” and core module mockups), using dimensional-mass and mechanically operating mockups of hardware and EVA systems.

Two training sessions each under pool conditions and two practical classes were held on EVA target tasks—installation of the OPM instrument on the DM and of the Benton dosimeter on the Kvant-2 module, and removal of the PIE and MSRE instruments.

Ground training of M. Foale for an unplanned EVA on 9/6/97 to inspect the exterior surface of the depressurized “Spektr” module was not held.

As a result of the training of the Russian-American EVA crew, operators consisting of Tsibliyev and Linenger (main crew) and Budarin and Foale (backup crew):

- acquired practical skills in installation of the OPM instrument on the DM and of the Benton dosimeter on the Kvant-2 module, and removal of the PIE and MSRE instruments;

- practiced elements of the EVA timeline in accordance with the flight data files;

- practiced actions in contingency off-nominal situations in accordance with the flight data files.

Training of NASA astronauts David Wolf and Andrew Thomas in the EVA program was conducted under conditions of modeled weightlessness in the pool and short-term weightlessness in the flying laboratory IL-76MDK.

Training for EVA under modeled weightlessness conditions in the pool was conducted on the *Mir* mockups (core module, Spektr, docking ring, DM) using the dimension-mass and mechanical operating mockups for SPSR and OPM in scuba gear, and in space suits “ORLAN-DMA-GN” No. 20 and “ORLAN-M-GN” No. 8. Scuba training of NASA astronauts was not conducted since the trainees already had scuba certificates.

When the scope of training for NASA astronaut David Wolf was determined, allowance was made for his prior experience in working in the EMU space suit at the JSC hydrolab. In addition, the conduct of standard EVA operations in scuba gear made it possible to reduce the total number of submersions of NASA astronaut David Wolf in the “Orlan-DMA(M)-GN” space suits.

In the process of training in standard EVA operations, the “Orlan-DMA(M)-GN” space suit, as well as the EVA program and procedures for measurement with the SPSR instrument, D. Wolf and A. Thomas had 3 practical classes each (10 hours).

D. Wolf and A. Thomas performed 4 checkout submersions in scuba gear and practical training in scuba gear for standard EVA operations (16 hours). In practicing the standard EVA operations in the EVA program (OPM removal and working with the SPSR), D. Wolf was submerged 4 times (16 hours) in the “Orlan-DMA(M)-GN” space suits. Learning the practical skills of donning and removing the space suit “Sokol-KV-2” and “Orlan-DMA-VL” flight modes, as well as working in these space suits in weightlessness under short-term weightless conditions on the flying laboratory IL-76MDK, D. Wolf and A. Thomas performed 1 flight (4 hours).

As a result of training under modeled weightless conditions in the pool and short-term weightlessness on the flying laboratory, NASA astronaut D. Wolf acquired:

- theoretical knowledge and practical skills in working in scuba gear;
- theoretical knowledge and practical skills in donning and removing the “Sokol-KV-2” space suit, the “Orlan-DMA-VL” space suit, and the “Orlan-DMA(M)-GN” space suit, as well as working in these space suits;
- practical skills in removing the OPM and working (measurement procedures) with the SPSR spectro-reflectometer.

NASA astronaut David Wolf acquired the skills of:

- standard EVA operations in scuba gear and in the “Orlan-DMA(M)-GN” space suit;
- EVA timeline elements in accordance with the flight data files;
- actions in contingency off-nominal situations.

As a result of training under conditions of modeled weightlessness in the pool and short-term weightlessness on the flying laboratory, NASA astronaut Andrew Thomas acquired:

- theoretical knowledge and practical skills of working in scuba gear;
- theoretical knowledge and practical skills in donning and removing the “Sokol-KV-2” space suit, the “Orlan-DMA-VL” space suit, and the “Orlan-DMA(M)-GN” space suit, as well as working in these space suits.

Training of NASA astronauts A. Thomas and J. Voss in the EVA program was conducted in the period from September 30, 1997 to November 30, 1997.

Training sessions were conducted in the space suits “ORLAND-DMA-GN” numbers 21 and 22 and space suits “ORLAN-M-GN” numbers 7 and 8. The training process utilized:

- the core module mockup;
- instrument science compartment mockup;
- special airlock mockup;
- Kvant module mockup;
- cargo boom on service stand;
- OPM science hardware dimensional mockup;
- SPSR science hardware dimensional mockup;
- “Truss-3” dimensional mockup;
- “Sofor” truss dimensional mockup;
- “Sofor” trust installation ring (KM);
- *Mir* orbital complex training mockup (1:20);
- EVA tool kit.

Scuba training of the NASA astronauts was not conducted since the trainees had their scuba certificates.

When the scope of training of NASA astronauts Andrew Thomas and James Voss was decided, allowance was made for their prior experience in working in the EMU space suit at the JSC hydrolab.

The total number of submersions of NASA astronauts Andrew Thomas and James Voss in the “Orlan-DMA(M)-GN” space suits was reduced owning to earlier practice in standard EVA operations in the process of scuba training.

When the number and duration of theoretical and practical classes of NASA astronaut Andrew Thomas were determined, allowance was made for his training as part of NASA-6.

Practice of standard EVA tasks in space suits was conducted in the process of astronaut training in standard EVA timelines.

In the process of training, the following were conducted with A. Thomas and J. Voss:

- theoretical and practical training in the EVA program (standard operations, terminology, tasks, training resources, science hardware), with A. Thomas 9 classes (13 hours), with J. Voss 10 classes (16 hours);
- practical training in scuba gear СВУ-3: A. Thomas did 3 training sessions (9 hours), while J. Voss did 4 training sessions (12 hours);
- in the “Orlan-DMA(M)-GN)” space suit, A. Thomas and J. Voss did 4 training sessions each (16 hours).

As a result of training for EVA on the *Mir* orbital complex, NASA-7 astronauts Andrew Thomas and James Voss acquired skills in performance of:

- standard EVA operations in scuba gear and in the “Orlan-DMA(M)-GN” space suit;
- standard EVA timelines in accordance with the flight data files;

- actions in contingent off-nominal situations.

In conclusion, the scope and content of training of the 4 NASA astronauts in the EVA program on the *Mir* were adequate for successful accomplishment of the program of 3 EVAs.

7.10 Summary of *Mir*-NASA Crew Training

The *Mir*-NASA joint flight program allowed the GCTC to accumulate considerable experience in training Russian-American crews. The GCTC trained American astronauts:

- on the transport vehicle: as cosmonaut-researcher in the transport vehicle descent stage (if emergency evacuation of the *Mir* was required);
- on the *Mir* orbital complex: as the flight engineer for individual systems of the *Mir* long-term mission;
- on EVAs jointly with the Russian cosmonaut in order to accomplish the science program, inspect the *Mir* and restore its functionality;
- on the joint science program at the GCTC and the JSC. Experience was acquired in medical certification and flight clearance of cosmonauts and astronauts.

The *Mir*-NASA joint flight program made it possible to accumulate considerable experience in the general work of interaction of the Russian-American space crews and experts.

The Russian Space Agency and NASA experts had an opportunity to become acquainted with one another, with the space centers of the partners, and with the system and specifics of training cosmonauts for spaceflights in Russia and in the U.S. The joint work furthered mutual improvements and development of common approaches to cosmonaut training, planning and implementation of space missions and measures associated with them. Cooperation in space by the Russian and American sides made it possible to approach the next stage in the conquest of space — the uniting of efforts to develop the ISSand to train the crews for its assembly and operation.

Astronaut Scott Parazynski performs an EVA during STS-86