MIPAS Mission Plan

Version 4.2, July 15, 2005

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1 Background

This mission plan is an update of the version 4.1 that was distributed in May 2005.

The mission plan V4.1 (May 3, 2005) replaced the last version of the prior mission plan (Version 3.4 of May 2002) that had been dedicated to MIPAS operations in nominal (full resolution) configuration. After an increasing frequency of problems with the interferometer drive system in late 2003 and beginning 2004 and upon subsequent detailed investigations it was decided that from January 2005 on MIPAS needed to be operated at reduced resolution (41% of nominal) and in a campaign mode with a duty cycle of 35 – 45 % (Ref.: 'MIPAS QWG-7 Instrument Status', Presentation by P. Mosner, EADS-Astrium, Firenze, 18-19 April 2005). The reduced duty cycle reflects investigations which show that, after some time of operation the number of failures of the interferometer drive unit increases, while after some switch-off time the interferometer recovers again (so-called self-healing). Furthermore, a new automatic IDU anomaly recovery procedure has been implemented at ESOC. This means that a controlled Stop/Restart at a specific point around every orbit is introduced that results in an ~ 4 min data gap (according to 14.4° in latitude or ~ 1600 km). In consequence, a complete revision of the mission plan has become necessary.

The residual time for atmospheric measurements is further reduced by calibration measurements which are operated according to the following strategy (Ref.):

- LOS sequence per week with new setting (2 PRIME (+ 2 BACKUP) consecutive orbits)
- RGC (radiometric gain calibration) explicitly planned once per day (1 scan of 200 DS + BB sweeps)
- WCC (wear control cycle) automatically performed after every transition to Heater (1 scan of 12 sweeps)
- DS offset every about 800 sec (1 scan of 12 sweeps)
- Several specific in-flight calibrations performed once to 6 times per year

On the basis of these constraints the MIPAS Science Team discussed thoroughly optimised observation modes as well as short and medium term mission scenarios at meetings that took place on 6 October 2004 and 3-4 March 2005. This document reflects the decisions achieved at the Science Team Meetings (Ref: Minutes of 1st MIPAS Science Team Meeting (SE-R&D-min-06-10-03\CZ), Minutes of 2nd MIPAS Science Team Meeting (SE-R&D-min-03-03-05\CZ)), completed with some refinements that became necessary after the meetings.

The basic rationale has been to give at short term (i.e. within the first half year of 2005) a strong weight to the special operation modes that are dedicated to specific scientific objectives since those have not or only sparsely been operated so far. On mid and long term the rationale shall reflect the best trade-off between instrumental constraints and the scientific need to satisfy both special objectives and the need for monitoring.

2 Observation modes

The reduced spectral resolution of 41% of the (original) nominal one at maintained interferometer sweep speed means that the time needed for a single scan (i.e. the observation of one single tangent altitude) is reduced accordingly to 1.64 sec (so-called Double Slide Reduced Resolution Mode, 2RR). Including turn-around time one sweep takes about 2.1 sec. This new interferometer setting is fixed for all measurement modes (also calibration). The gain in time can be used for a finer vertical sampling, a larger coverage of altitude ranges, or a finer along-track sampling. Several recent studies (Ref.) have shown that oversampling in the vertical and/or the spatial domain can be utilized to achieve a higher resolution in these domains, provided the retrieval systems are tailored accordingly (e.g. regularization, 2-D retrievals). Accordingly, recent scientific studies have revealed an increased need for higher spatial resolution, particularly in the UTLS region. The new observation modes composed and listed below are reflecting these new capabilities and objectives.

2.1 Proposed Future Nominal Mode

The nominal mode is the basic mode to study chemistry and transport and to provide a data basis for climatology and trend analyses issues. It should cover the upper troposphere, the stratosphere and the lower mesosphere (boundaries 7-70 km). A floating altitude-sampling grid is proposed in order to follow roughly the tropopause height along the orbit with the requirement to collect at least one spectrum within the troposphere but to avoid too many cloud-affected spectra which are hard to analyse. After some iterations the following formula was proposed finally:

minimum_tangent_altitude = C – D * cos (90° – |tangent_point_latitude|)

with C=12 km and D=7 km

The sampling grid shall be finer in the UTLS region where the variability of the atmosphere is highest and small scale features are more present (1.5 km steps) and shall be widened to up to 4.5 km steps in the lower mesosphere. The altitude coverage goes from 5 to 69 km at the poles and from 12 to 76 km at the equator. The number of scans is then 27 according to an along track sampling of about 410 km. Table 1 lists important parameters and the tangent altitudes for 90°, 45° and 0° latitude.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25 and 40° Southern latitude during the Northern winter (1^{st} Dec. to 30^{th} Apr.) and between 25 and 40° N during the Southern winter (1^{st} May to 30^{th} Nov), if not otherwise specified in the operational scenario (Table 4).

Table 1: Nominal observation mode

Mode	**NOM**		
Floating altitude grid	yes		
# of altitude grid points	27		
Approx. along track sampling (km)	410		
Sample Latitude	90°	45°	0°
Tangent altitudes (km)			
	5	7.05	12
	6.5	8.55	13.5
	8	10.05	15
	9.5	11.55	16.5
	11	13.05	18
	12.5	14.55	19.5
	14	16.05	21
	15.5	17.55	22.5
	17	19.05	24
	18.5	20.55	25.5
	20	22.05	27
	22	24.05	29
	24	26.05	31
	26	28.05	33
	28	30.05	35
	30	32.05	37
	33	35.05	40
	36	38.05	43
	39	41.05	46
	42	44.05	49
	45	47.05	52
	49	51.05	56
	53	55.05	60
	57	59.05	64
	61	63.05	68
	65.5	67.55	72.5
	70	72.05	77

2.2 Proposed Future Special Modes

The team agreed on defining six new special modes (replacing the existing 11 special modes):

UTLS-1	Upper Troposphere Lower Stratosphere (primary UTLS mode)
UTLS-2	Upper Troposphere Lower Stratosphere (Test mode for 2-D retrievals)
MA	Middle Atmosphere
NLC	Middle/Upper atmosphere in summer (Noctilucent clouds)
UA	Upper Atmosphere
AE	Aircraft Emissions

Characteristic parameters and tangent altitudes of these special modes are compiled in Table 2. The scientific objectives and the rationale for these modes are outlined in the following.

2.2.1 UTLS-1 Upper Troposphere Lower Stratosphere Primary Mode

This mode is tailored to studies of atmospheric processes in the UTLS region (including the TTL (Tropical Transition Layer)). It provides a trade-off between vertical and horizontal resolution as well as vertical coverage. The vertical coverage is from the upper troposphere to the upper stratosphere with a strong weight of the UTLS region, ensuring a fine vertical and along-track sampling between the upper troposphere and the middle stratosphere. A floating altitude-sampling grid shall be applied according to the following settings:

minimum_tangent_altitude = A + B * cos (2*tangent point latitude)

with A=8.5 km and B=3 km

The number of samples per limb sequence is 19 and the along track sampling is only about 290 km.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25 and 40° Southern latitude during the Northern winter (1^{st} Dec. to 30^{th} Apr.) and between 25 and 40° N during the Southern winter (1^{st} May to 30^{th} Nov).

2.2.2 UTLS-2 Upper Troposphere Lower Stratosphere Test Mode

This mode ensures an even higher spatial sampling to test the capabilities of 2-D retrievals for increasing the along-track resolution. For this purpose the altitude range is restricted to the lower stratosphere. The number of scans is only 11 resulting in an along track sampling of only about 180 km.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25 and 40° Southern latitude during the Northern winter (1^{st} Dec. to 30^{th} Apr.) and between 25 and 40° N during the Southern winter (1^{st} May to 30^{th} Nov).

2.2.3 MA Middle Atmosphere Mode

The MA mode covers most part of the stratosphere, the mesosphere and the lower thermosphere (from 18 to 102 km) with 29 steps at a constant 3 km step size. The along-track sampling is about 430 km. This mode replaces the old MA mode and reflects the experience gained with the former modes for the middle and upper atmosphere. This mode is dedicated to study linkages between the upper atmosphere and the stratosphere, i.e. the global circulation and transport from CO and NOx from the mesosphere down to the stratosphere in polar winter hemispheres, as well as Solar Proton Events affecting both the upper atmosphere and the stratosphere. The mode is also used to monitor the quality of operational retrievals that are neglecting non-LTE effects.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25-40°S in December and March and 25-40°N in June and September; always in the descending node.

2.2.4 UA Upper Atmosphere Mode

The UA mode covers the altitude region from 42 to 172 km with 35 scans. The step size is 3 km from 42 to 102 km, and 5 km above. The along-track sampling is about 515 km. This mode is mainly dedicated to measurements of high-altitude NO.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25-40°S in December and March and 25-40°N in June and September; always in the descending node

2.2.5 NLC Middle/Upper atmosphere in summer (Noctilucent clouds)

This mode corresponds to the UA mode but is truncated at 102 km altitude. Instead, three additional layers at 79.5 km, 82.5 km, and 85.5 km are inserted in order to optimise the detection of noctilucent clouds which appear regularly in the polar summer mesopause region.

The data gap introduced by the IFM Stop/Restart procedure should be placed between about 25-40°N in Southern (Austral) summer (December) and 25-40°S in Northern summer (June/July), always in the descending node.

2.2.6 AE Aircraft Emissions Mode

The AE mode is dedicated to the detection of aircraft emissions and their effects on the chemistry in the upper troposphere and lowermost stratosphere. This is the only mode for applying the Cross-track capability of MIPAS measurements. The sampling will be optimized to the 7 to 13 km altitudes (1.5 km sampling) where the expected effect is largest. Some layers are added on top in order to restrict the sensitivity of the retrieval to altitude regions above the aircraft corridor. The number of samples per sequence is 12. The azimuth should be optimized such that the lines of sight are as parallel as possible to the aircraft corridors to enable long optical paths inside the aircraft corridors and a high contrast between measurements within the aircraft corridors and those in adjacent ‘unaffected’ regions of the atmosphere. For the time being, the North Atlantic Corridor has been selected for the study since it is the most confined corridor with the highest traffic. In addition, it connects the polluted areas of North America and Europe. The mode should be activated in the sector 30-70° Latitude North, 80°W-20°E Longitude in order to meet the scientific requirements.

Note added in V4.2: According to a software constraint, there is a maximum of 19 continuous single SEM scans, which - for the new reduced spectral resolution of MIPAS - limits the coverage to 28° in latitude only. For the time being, we suggest then to activated the aircraft emission mode in the 36-64° latitude range. However, it is highly recommended to investigate by which means the whole 40° latitude range, as proposed originally, can be realized in future. One alternative could be, for example, to adapt the latitude sector to the longitude by centering the 28° maximum range around the core part of the North Atlantic corridor (or, with other words around the most red parts of Figure 1). In the latter case, the scientific objectives of the AE mode could be even achieved with the 28° maximum latitude range.

The data gap introduced by the IFM Stop/Restart procedure should be placed at 25-40°S.

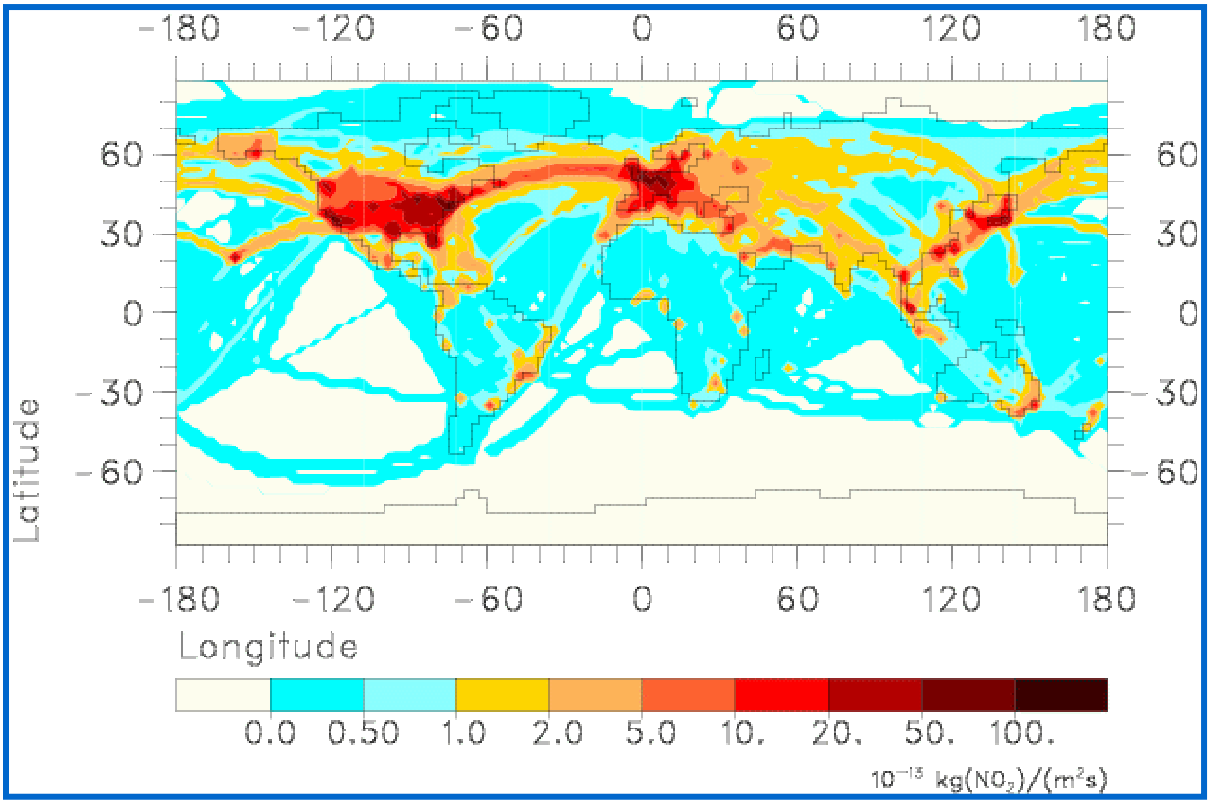

Fig.1: Distribution of aircraft emissions (*Köhler el al., Contribution of aircraft emissions to the atm. NOx content, Atmos. Environ. 31, 1801-1818, 1997*).

Table 2: Special observation modes

Mode	UTLS-1		UTLS-2	MA	NLC	UA	AE
Floating altitude grid	yes		no	no	no	no	no
# of altitude grid points	19		11	29	25	35	12
Approx. along track sampling (km)	290		180	430	375	515	n.a.
Sample Latitude	90°	0°	0-90°	0-90°	0-90°	0-90°	Sector *
Tangent altitudes (km)							
	5.5	11.5	12	18	39	42	7
	7	13	14	21	42	45	8.5
	8.5	14.5	16	24	45	48	10
	10	16	18	27	48	51	11.5
	11.5	17.5	20	30	51	54	13
	13	19	23	33	54	57	15
	14.5	20.5	26	36	57	60	17
	16	22	29	39	60	63	20
	17.5	23.5	33	42	63	66	24.5
	19	25	37	45	66	69	29
	21	27	42	48	69	72	33.5
	23	29		51	72	75	38
	25	31		54	75	78	
	28	34		57	78	81	
	31	37		60	79.5	84	
	35.5	41.5		63	81	87	
	40	46		66	82.5	90	
	44.5	50.5		69	84	93	
	49	55		72	85.5	96	
				75	87	99	
				78	90	102	
				81	93	107	
				84	96	112	
				87	99	117	
				90	102	122	
				93		127	
				96		132	
				99		137	
				102		142	
						147	
						152	
						157	
						162	
						167	
						172	

* Proposed latitude-longitude sector to be covered by AE mode for the North-Atlantic flight corridor: 30-70° Latitude North, 80°W-20°E Longitude.

2.3 Mission Scenario

In the short term (i.e. particularly within the first half year of 2005) a strong focus should be given to the special operation modes that are dedicated to specific scientific objectives since those have not or only sparsely been operated so far.

On mid and long term the rationale shall reflect the best trade-off between instrumental constraints and the scientific need to satisfy both special objectives and the need for monitoring.

The mission plan is defined in detail for the year 2005 only. It needs to be refined and set up for 2006 at the next meeting of the MIPAS Science Team (scheduled for September 2005) on the basis of experiences made with the observation modes (and related data analysis) operated until then and the instrument status by then. The mission plan takes into account the currently proposed duty cycle of ~ 35 – 45 %.

The actual orbit planning needs to be flexible when validation or scientific field campaigns are taking place (e.g. in June 2005 during the Teresina ESABC balloon campaign and in November/Dezember 2005 during the SCOUT aircraft campaign to take place from Darwin/Australia). Adjustments of the proposed mission plan will be necessary to ensure the best possible coverage of the campaign measurement area and period. Normally, this can be done 2-4 weeks prior to the start of the field campaign activities.

Table 3: MIPAS Short-Term Operational Scenario as agreed during MIPAS STM-1.

Time (2005)	**Mode**	**Operational Scenario**	**Objective**
20-23 March	Nominal	3 continuous days	Monitor Arctic
27-30 March	MA	3 continuous days	Monitor Middle Atmosphere
04-07 April	Nominal	3 continuous days	Monitor Arctic
12 April	UA	1 continuous day	Monitor Upper Atmosphere
17-20 April	UTLS-1	3 continuous days	Monitor UT/LS
5-6 May 2005	Nominal including AE	1 continuous day	Test the feasibility to measure Aircraft Emissions (Northern Atlantic Flight Corridor)

Table 4: Preliminary MIPAS Mid-Term Operational Scenario (updated July 15, 2005)

Time (2005)	**Mode**	**Operational Scenario**	**Objective**
First two weeks of May	Nominal	2x3 continuous days 2x4 continuous days off	Monitor Climatology and Trends
mid May – 19 June (to be harmonised with planned Teresina ESABC campaign)	Nominal alternating with UTLS-1	8 orbits operations followed by 16 orbits switch-off	Monitor Onset and Evolution of Antarctic PSCs
21-23 June (to be harmonised with planned Teresina ESABC campaign)	Nominal	3 continuous days	Monitor Antarctic Winter
27 June – mid July (to be harmonised with planned Teresina ESABC campaign)	2*UTLS-1 1*Nominal	3x3 continuous days on 3x4 continuous days off	Monitor Indian Monsoon (+PSC evolution)
19 – 23 July	3*NLC 1*UA	4 continuous days	Detection of Noctilucent Clouds (NLCs) & Upper Atmosphere in coordination with comprehensive measurement campaign of ground-based instruments
26 – 29 July	Nominal with embedded AE	1 day of aircraft emissions (SEMs)	Detection of Aircraft Emissions in the North Atlantic Flight Corridor
First half of August	Nominal	2x3 continuous days 2x4 continuous days off	Monitor Climatology and Trends
Second half of August	UTLS-1	2x3 continuous days 2x4 continuous days off	UTLS dedicated research
First half of September	Nominal	2x3 continuous days 2x4 continuous days off	Monitor Climatology and Trends
15 – 18 September	MA UA	3 days 1 day	Equinox
20 – 30 September	UTLS-1	Selected orbits	ASA balloon campaign
First half of October	Nominal	2x3 continuous days 2x4 continuous days off	Monitor Climatology and Trends
Second half of October	UTLS-1 AE (along with	3 continuous days 3 continuous days	UTLS-Research Detection of Aircraft

	NOM)		Emissions in the North Atlantic Flight Corridor
First half of November (to be harmonized with SCOUT campaign)	Nominal	2x3 continuous days 2x4 continuous days off	Monitor Climatology and Trends
Second half of November (to be harmonized with SCOUT campaign)	UTLS-1	2x3 continuous days 2x4 continuous days off	UTLS dedicated research
First half of December (to be harmonized with SCOUT campaign)	Nominal UTLS-1	3 continuous days followed by 4 days off 8 orbits operations followed by 16 orbits switch-off	Monitor Climatology and Trends Monitor Onset and Evolution of Arctic PSCs
Second half of December (to be harmonized with SCOUT campaign)	UTLS-1 NLC UA	8 orbits operations followed by 16 orbits switch-off 3 days 1 day	Monitor Onset and Evolution of Arctic PSCs Northern Winter solstice

The MIPAS Long-Term Operational Scenario shall meet the following requirements:

- Depending on the MIPAS instrument operational behaviour once per month 3 continuous days in nominal and UTLS-1 mode should be performed.
- Specific measurements should be foreseen per year to monitor Arctic/Antarctic winter and to perform every 3 months MA and UA modes (especially at Solstice and Equinox).
- In case the UTSL-2 measurements, which have been performed already once so far, are good there is no need to repeat these measurements for another time.
- AE measurements should be performed at least once/year (preferably during winter time). Please note that AE measurements will have been performed already in 2005 in three different seasons.
- Special field campaigns (e.g. in support to the EC projects SCOUT and AMMA) should be taken into account in terms of an adjusted mission planning, whenever feasible, to enable the best possible synergy between satellite measurements and filed measurements.
- The requirements of a possible MIPAS operational scenario for MIPAS measurements to be used in operational data assimilation systems should be investigated.