lisa pathfinder FIRST STEPS TO OBSERVING

LISA Pathfinder

Paul McNamara on behalf of the LPF collaboration LISA Pathfinder Project Scientist European Space Agency

ESA UNCLASSIFIED - For Official Use









LISA Pathfinder

- Control LISA Pathfinder was selected by ESA to test the critical technologies for LISA which cannot be tested on the ground
 - Arm shrunk from million km to 10's cm
 - Gives up sensitivity to gravitational waves
 - Maintains (and worsens) instrument noise

Construction of the second state of the sec

- Science Operations began in 1 March 2016
- Science Operations ended on 30 June 2017
 - Last telecommand will be sent at 18:00UTC on 18 July
- Performance has far exceeded our most optimistic (pre-launch) expectations
 - We have demonstrated the full LISA performance over the LISA measurement bandwidth goal

ESA UNCLASSIFIED - For Official Use

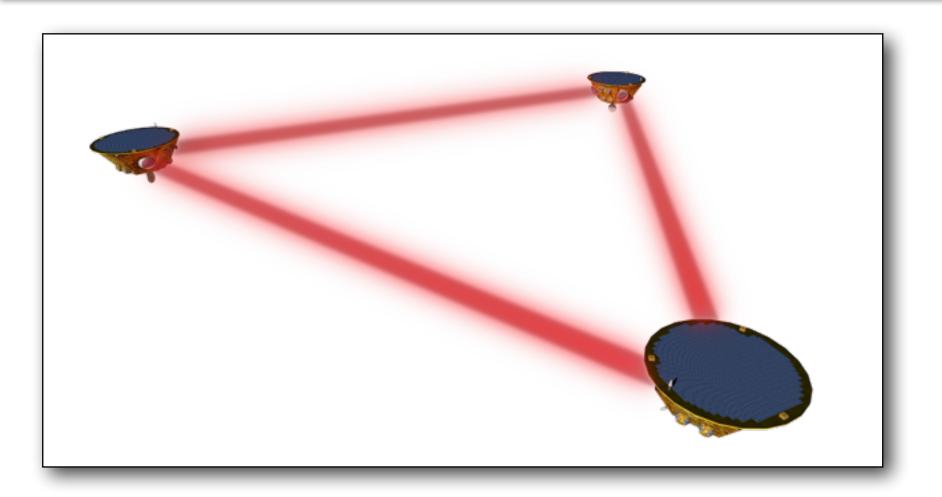






*





ESA UNCLASSIFIED - For Official Use





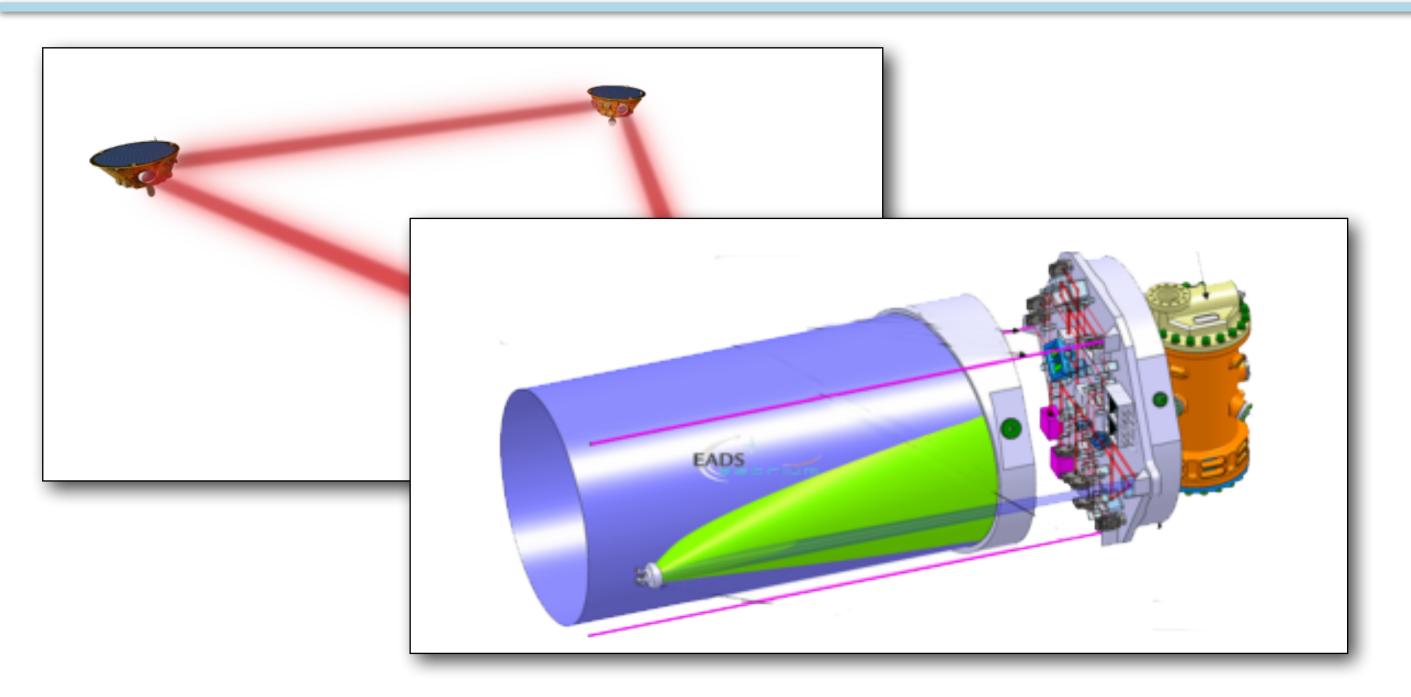
LISA:

- 3 spacecraft, separated by ~million km

- Role of each spacecraft is to protect the fiducial test masses from external forces







ESA UNCLASSIFIED - For Official Use



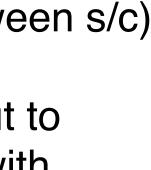


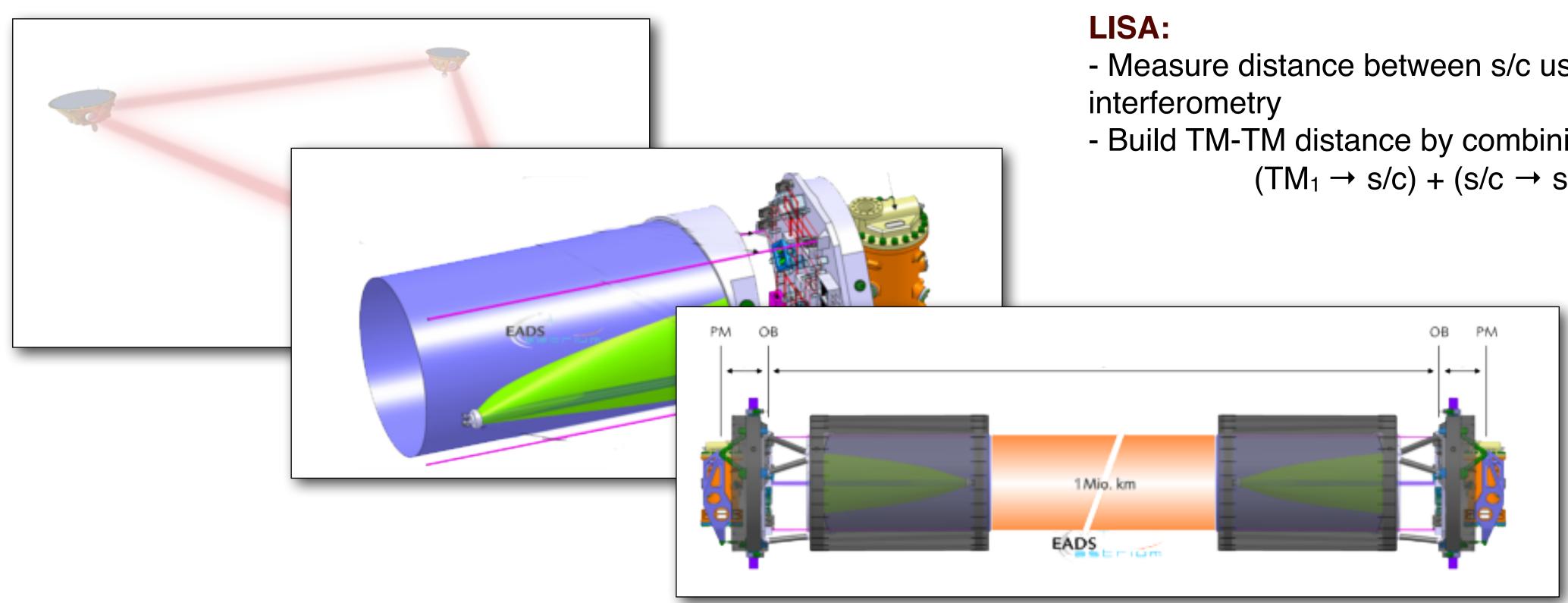
LISA:

- Locally measure distance from TM to s/c using:
 - Laser interferometry along sensitive axis (between s/c)
 - Capacitive sensing on orthogonal axes

- TM displacement measurements are used as input to DFACS which controls position and attitude of s/c with respect to the TM







ESA UNCLASSIFIED - For Official Use





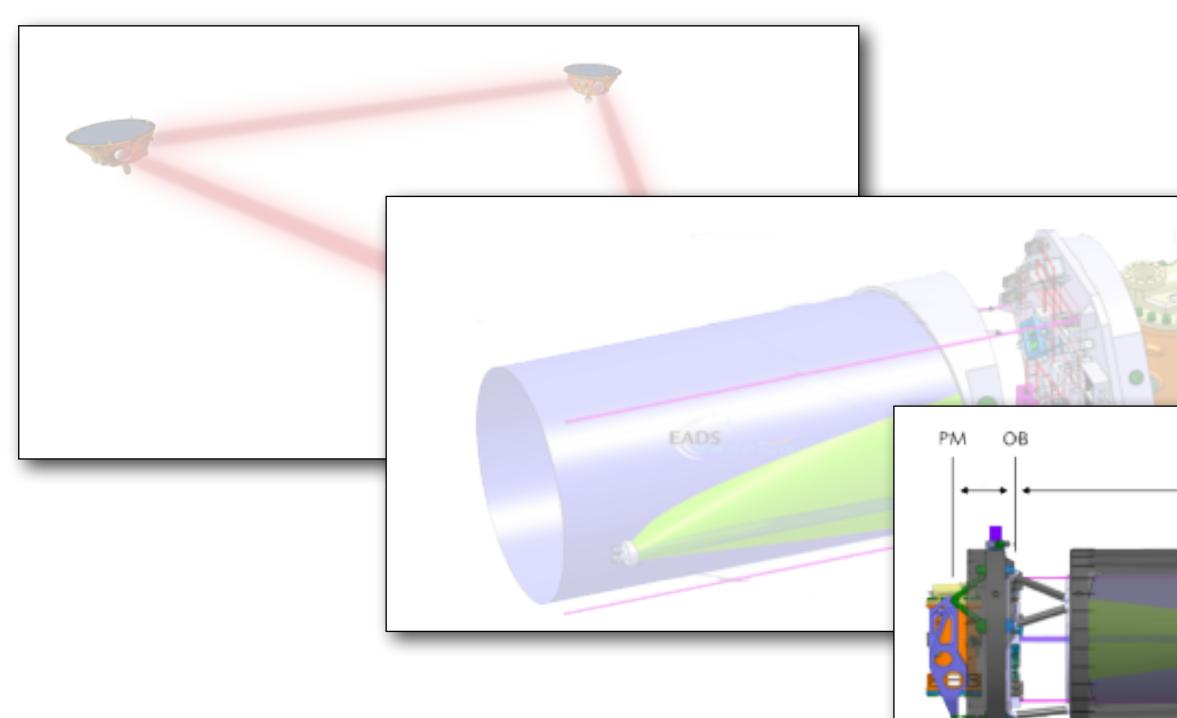
- Measure distance between s/c using laser

- Build TM-TM distance by combining:

```
(TM_1 \rightarrow s/c) + (s/c \rightarrow s/c) + (s/c \rightarrow TM_2)
```

Amaldi 12 | 12-07-2017 | Slide 5





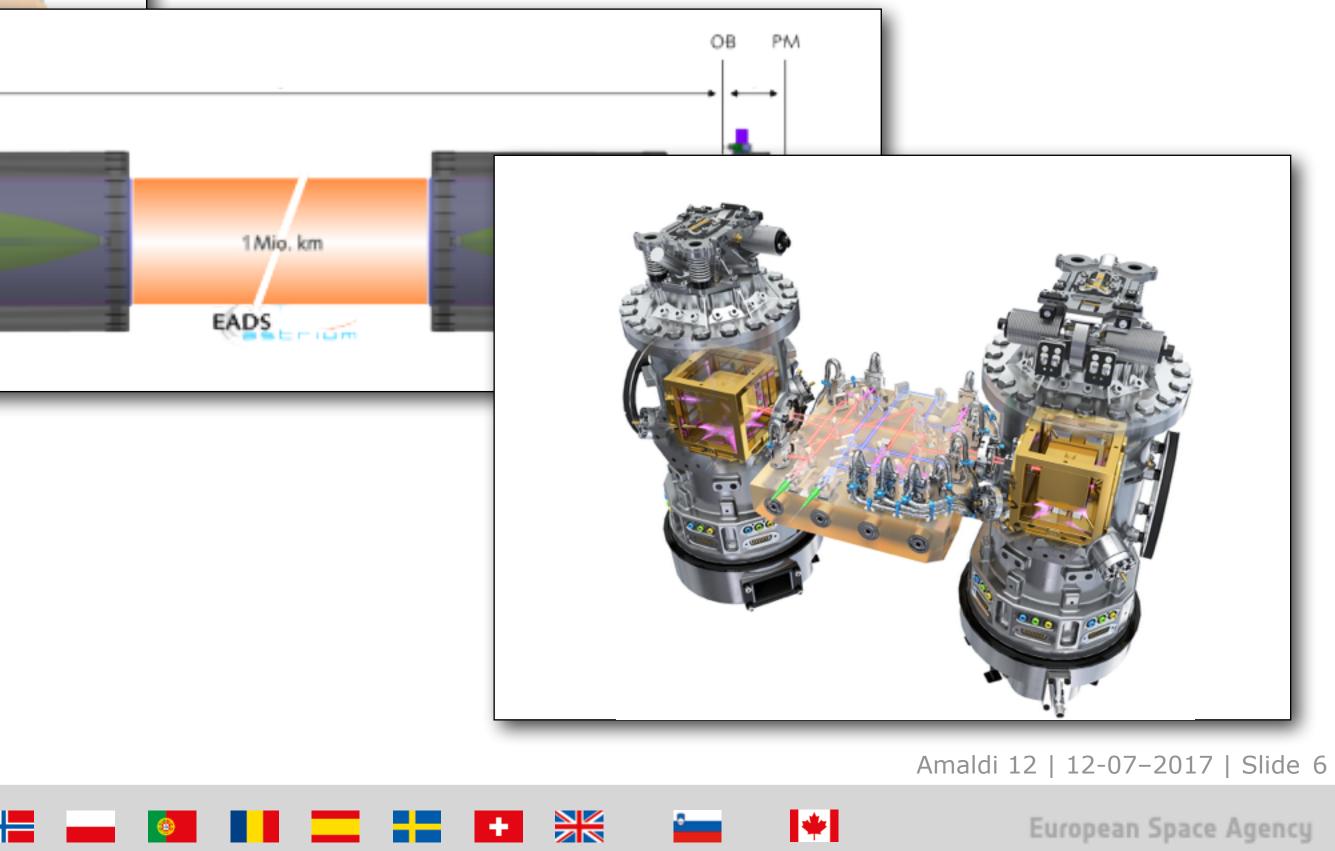
ESA UNCLASSIFIED - For Official Use





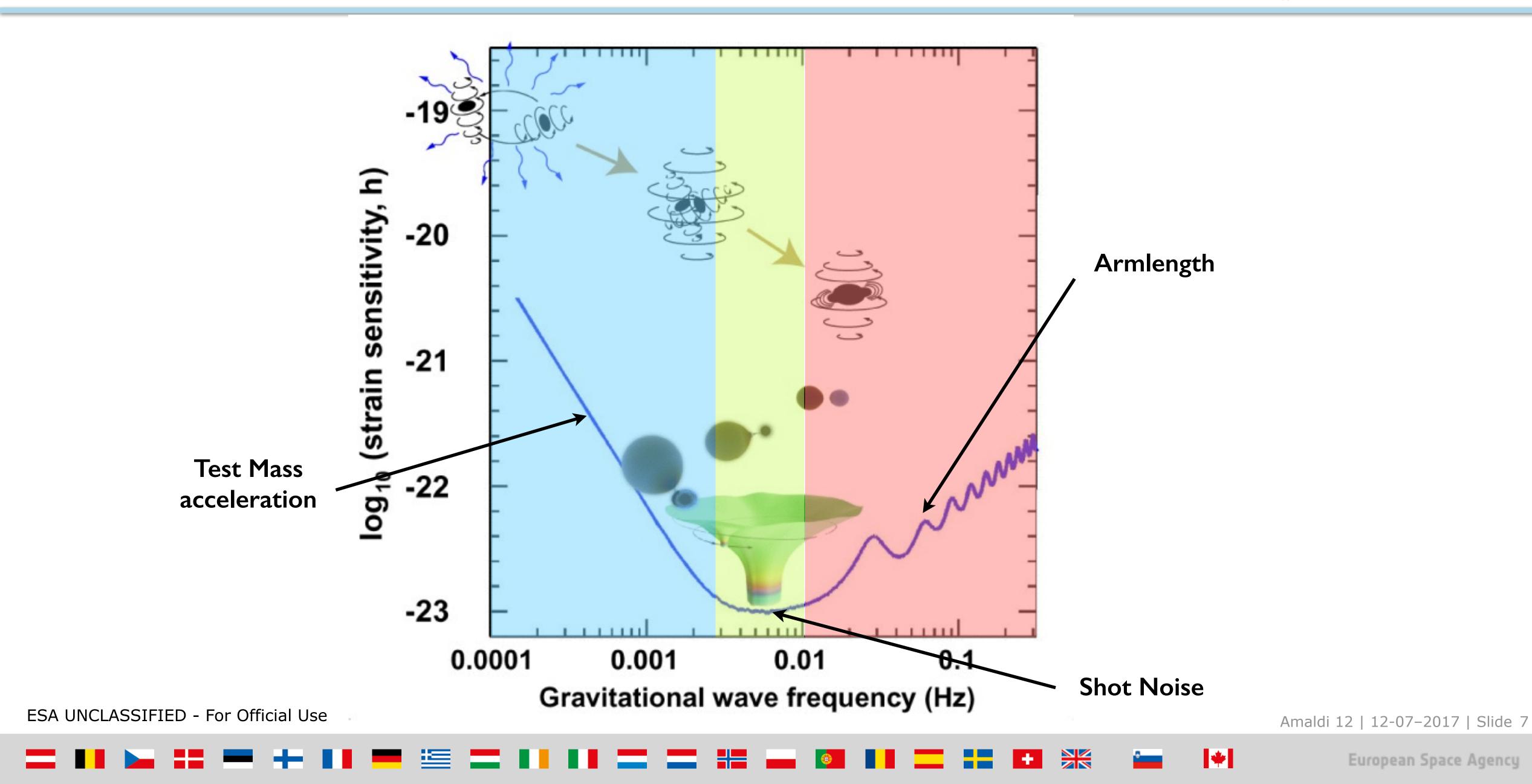
LISA Pathfinder:

- Two test masses/two inertial sensors
- Laser interferometric readout of $TM_1 \rightarrow s/c \& TM_1 \rightarrow TM_2$
- Capacitive readout of all 6dof of test masses
- Drag-Free and Attitude Control System
- Micro-Newton Thrusters





LISA Sensitivity Curve





LISA Pathfinder

LISA Pathfinder consists of:

- Spacecraft

- Provided by ESA
 - Industrial Prime Contractor: Airbus DS (UK)
- s/c also includes the drag free control software and micro-Newton thrusters

- Payloads

• The LISA Technology Package (LTP)

- Provided by European member states and ESA
- Consists of inertial sensors, interferometric readout, payload computer and diagnostic subsystem

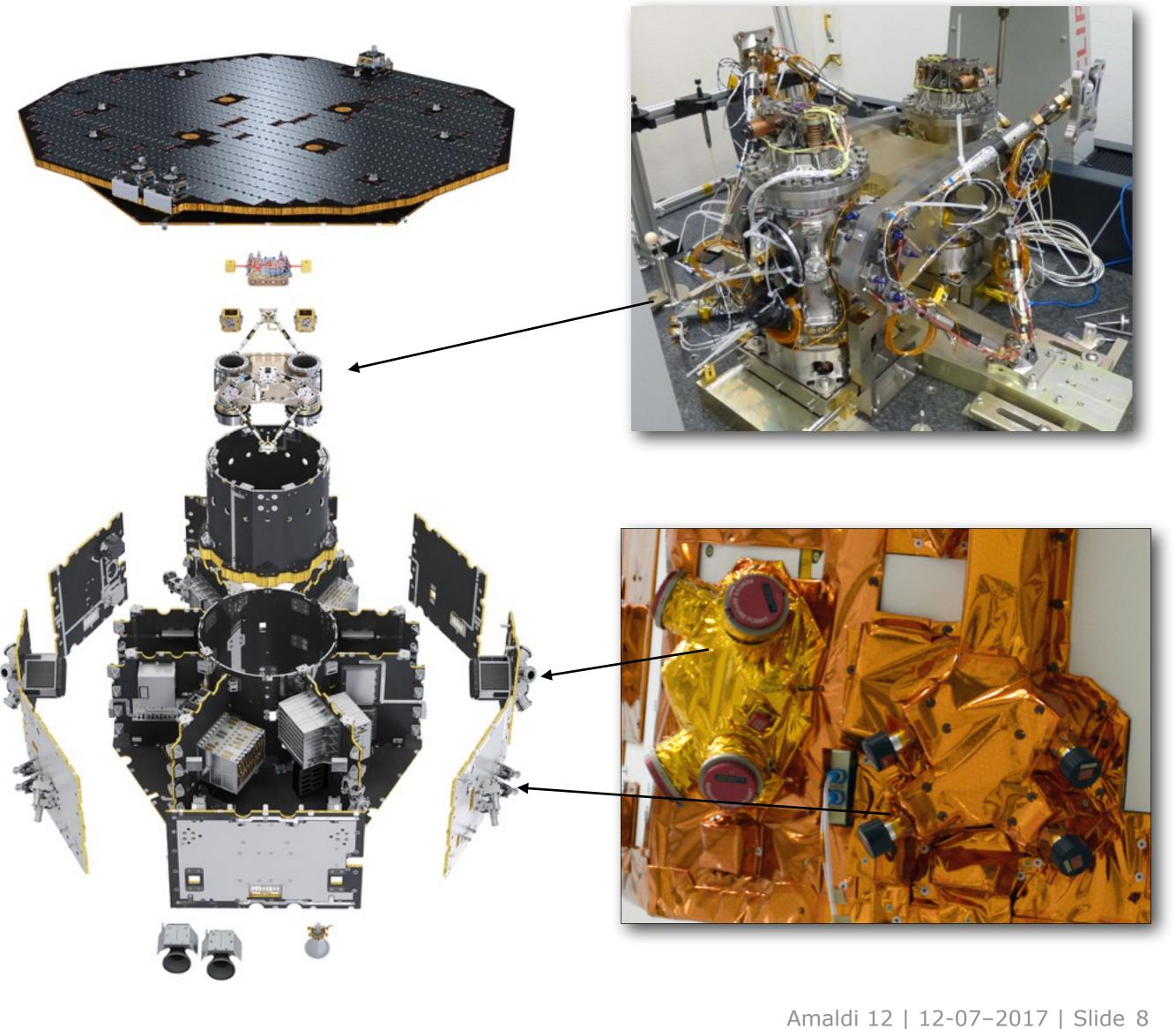
• The Disturbance Reduction System (DRS)

- Provided by NASA/JPL
- Consists of processor running drag-free control software and micro-Newton thrusters

ESA UNCLASSIFIED - For Official Use









+





Constraints in going to space...

Vibration

- During launch we subject our very delicate s/c to ~141dB of white noise
 - This is similar to a jumbo jet taking off

Ce Thermal

- Payload temperature range: 0C to +40C
- Solar array temp range: -130C to +130C

Radiation

- Radiation-hard components are not state-of-the-art!
 - On-board computer clock speed = 22.5MHz

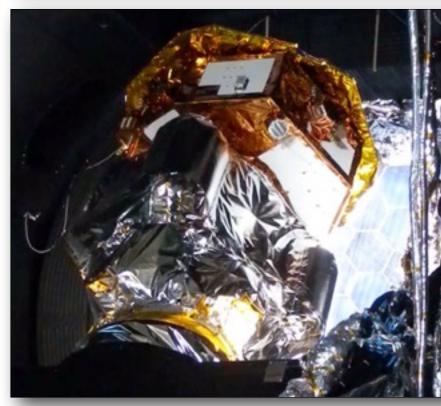
Communications

- Ground contact = 8 hours/day with 56kbps link
 - ~200MB of data per day maximum from s/c
 - Similar to 1990's dial-up modems

ESA UNCLASSIFIED - For Official Use









Amaldi 12 | 12-07-2017 | Slide 9









*





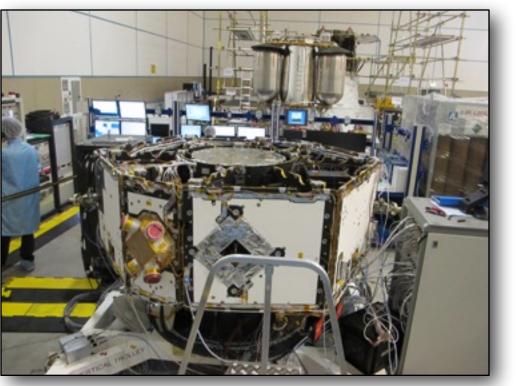


"Commissioning" of LPF

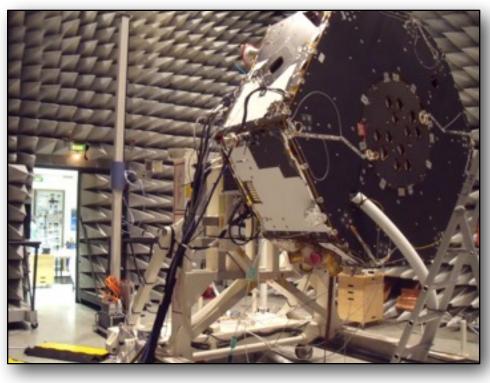
© The (LIGO-like) commissioning of a space mission happens before launch - On orbit commissioning of LPF was a functional check-out of equipment



Vibration/shock tests



Closed-loop tests



EMC

ESA UNCLASSIFIED - For Official Use



On-Station Thermal Test







Transfer Orbit Thermal Test



Launch Vehicle Fit Check

Credit: Airbus Defence and Space and IABG Amaldi 12 | 12-07-2017 | Slide 10





Preparing for launch...



> LISA PATHFINDER PREPARES FOR LIFTOFF





11

LISA Pathfinder Launch

LISA Pathfinder was launched on 3/12/2015 at 04:04UTC



ESA UNCLASSIFIED - For Official Use



Amaldi 12 | 12-07-2017 | Slide 12



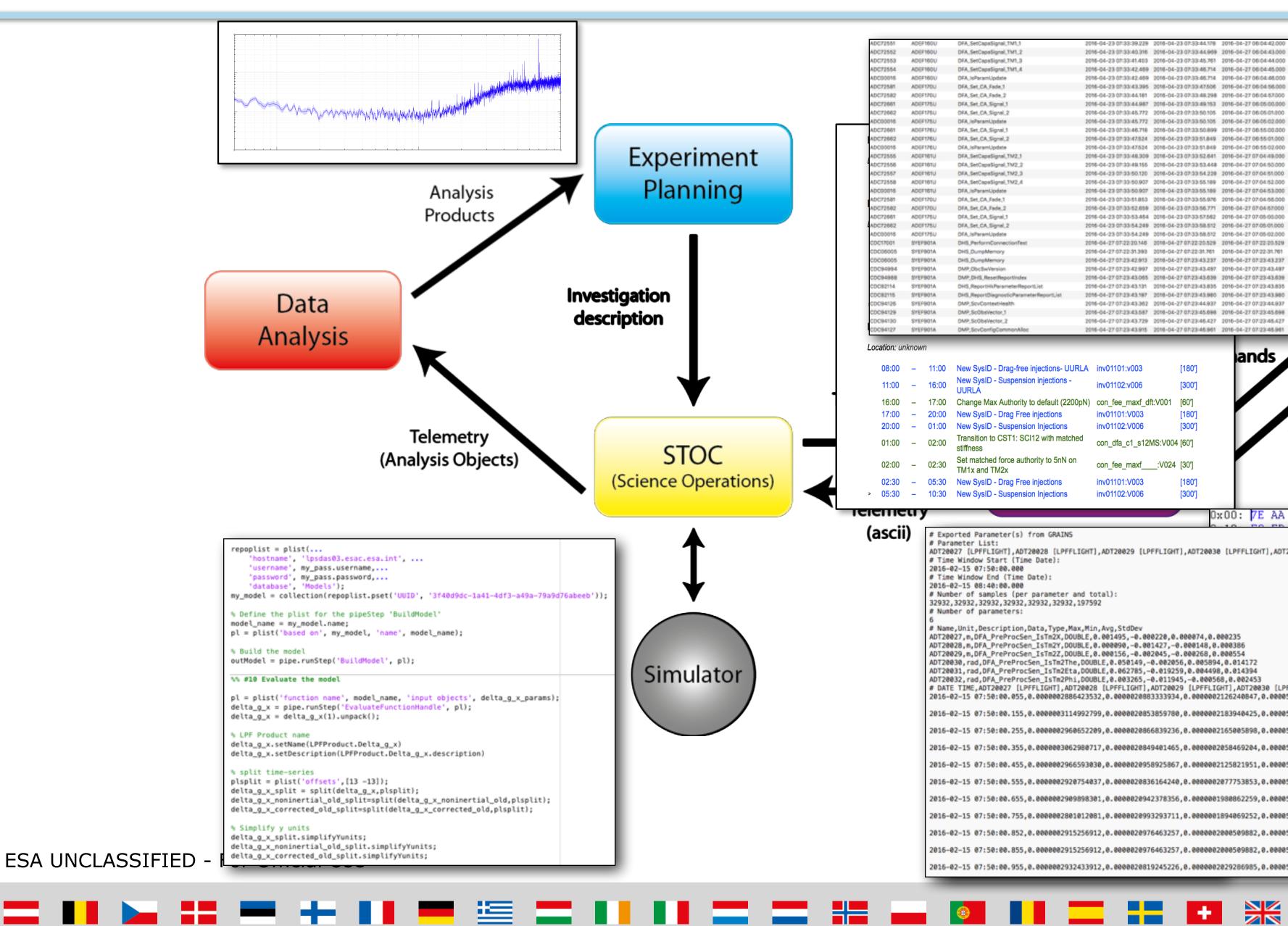
En-route to L1

- Orbit raised via 6 apogee raising manoeuvres
- Transfer to Lagrange Point (L1) took ~50 days
- Separation of propulsion module on 2 February
- Final Orbit:
 - 500,000km x 800,000km around L1
 - Orbital Period of 6 months



13

A orbiting physics lab





ADC72561		F160U	DFA_SetCapaSignal_TM1_1	2016-04-23 07:33:39.229	2016-04-23 07:33:44.178	2016-04-27 06:04:42:000		
ADC/2562		F160U	DFA_SetCapaSignal_TM1_2			2016-04-27 06:04:43.000		
ADC72553		F160U	DFA_SetCepaSignal_TM1_3			2016-04-27 06:04:44.000		
ADC72554 ADC00016		F160U F160U	DFA_SetCepsSignal_TM1_4 DFA_IsParamUpdate			2016-04-27 06:04:45:000 2016-04-27 06:04:45:000		
ADC72581	ADEF		DFA, Set, CA, Fade, 1		2016-04-23 07:33:47.506			
ADC72582	ADEF	F170U	DFA_Set_CA_Fade_2	2016-04-23 07:33:44.181	2016-04-23 07:33:48.298	2016-04-27 06:04:57.000		
ADC72661	ADEF	F176U	DFA_Set_CA_Signal_1	2016-04-23 07:33:44.987	2016-04-23 07:33:49.153	2016-04-27 06:05:00.000		
ADC72662	ADEF	F176U	DFA_Set_CA_Signal_2	2016-04-23 07:33:45.772	2016-04-23 07:33:50.105	2016-04-27 06:05:01.000		
ADC00016	ADEF		DFA_IsParamUpdate		2016-04-23 07:33:50.105			
ADC72661	ADEF		DFA_Set_CA_Signal_3			2016-04-27 06:55:00.000		
ADC72662 ADC00016	ADEF		DFA_Set_CA_Signal_2 DFA_isParamUpdate		2016-04-23 07:33:51.849	2016-04-27 06:55:02.000		
ADC72555	ADEF		DFA_SetCapaSignal_TM2.1		2016-04-23 07 33 52 641			
ADC72556	ADEF		DFA_SetCapaSignal_TM2_2			2016-04-27 07:04:50.000		
ADC72557	ADEF	F161U	DFA_SetCapaSignal_TM2_3	2016-04-23 07:33:50.120	2016-04-23 07:33 54.228	2016-04-27 07:04:51.000		
ADC72558	ADEF	F161U	DFA_SetCapaSignal_TM2_4	2016-04-23 07:33 50.907	2016-04-23 07:33 55.189	2016-04-27 07:04:52:000		
ADC00016	ADDF	F161U	DFA_isParamUpdate	2016-04-23 07:33:50.907	2016-04-23 07:33 55.189	2016-04-27 07:04:53.000		
ADC72581	ADDF		DFA_Set_CA_Fede_1			2016-04-27 07:04:55:000		
ADC72582	ADDF		DFA_Set_CA_Fede_2		2016-04-23 07:33:56.771			
ADC72661	ADEF		DFA_Set_CA_Signal_1		2016-04-23 07:33 57:562 2016-04-23 07:33 58:512			
ADC72662 ADC00016	ADDF		DFA_Set_CA_Signal_2 DFA_isPeramUpdate		2016-04-23 07:33 58:512		and the second se	
CDC17001	SYEP		DHS, PerformConnectionTest		2016-04-27 07:22:20.529			and the second se
CDC08005	SYEP		DHS.DumpMemory		2016-04-27 07:22:31.761			and the second s
CDC06005	SYEP	PBO1A	DHS_DumpMemory	2016-04-27 07:23:42.913	2016-04-27 07:23:43.237	2016-04-27 07:23:43.237		
CDC94994	SYEP	PBO1A	DMP_ObcSwVersion	2016-04-27 07:23:42.997	2016-04-27 07:23:43.497	2016-04-27 07:23:43.497		
CDC94988	SYEP		DMP_DHS_ResetReportIndex			2016-04-27 07:23:43.639		
CDC82114	SYEP		DHS,ReportHkParameterReportList		2016-04-27 07:23:43.835			
CDC82115 CDC94125	SYEP		DHS_ReportDiagnosticParameterReportList DMP_ScvContextHealth	2016-04-27 07:23:43:197	2016-04-27 07:23:43.980 2016-04-27 07:23:44.937	2016-04-27 07:23:43.980		
CDC94129	SYEP		DMP_ScObsVector_1	2016-04-27 07-23-43-567		2016-04-27 07:23:45:698		
CDC94130	SYEP		DMP.ScObsVector_2			2016-04-27 07:23:46.427		and the second sec
CDC94127	SYEP		DMP_ScvConfigCommonAlloc		2016-04-27 07:23:46.961			
Location: un	knowi	'n				a n da		
						ands		
08:00	-	11:00	New SysID - Drag-free injections- UURL	A inv01101:v003	[180']			
			New SysID - Suspension injections -		10000			
11:00	-	16:00	UURLA	inv01102:v006	[300']			
16:00	_	17:00	Change Max Authority to default (2200p	N) con_fee_maxf_d	ft:V001 [60']			
			• • • • •					
17:00	-	20:00	New SysID - Drag Free injections	inv01101:V003	[180']			
20:00	-	01:00	New SysID - Suspension Injections	inv01102:V006	[300']		- 1 .	
01.00		02.00	Transition to CST1: SCI12 with matched	con dfa at at2			Telemetry	
01:00	-	02:00	stiffness	con_dfa_c1_s12	MS:V004 [60]			
			Set matched force authority to 5nN on				(Dl)	
00.00		02.20	Set matched force authority to only on	oon foo movf	AV004 1000		(VacVatc)	
02:00	-	02:30	TM1x and TM2x	con_iee_maxi	:V024 [30']		(Packets)	
			TM1x and TM2x				(Packets)	
02:00	_	05:30	New SysID - Drag Free injections	inv01101:V003	[180]		(Packets)	
		05:30					(Packets)	
02:30 > 05:30	-	05:30 10:30	New SysID - Drag Free injections	inv01101:V003	[180]		(Packets)	
02:30	-	05:30 10:30	New SysID - Drag Free injections	inv01101:V003	[180'] [300']	x00: 7E AA	(Packets) 92 40 40 40 40 62 9E F4 6	4 86 AA 84 61 03
02:30 > 05:30	- ,	05:30 10:30	New SysID - Drag Free injections New SysID - Suspension Injections	inv01101:V003	[180'] [300']	×00: 7E AA	•	
02:30 > 05:30	- ,	05:30 10:30	New SysID - Drag Free injections New SysID - Suspension Injections	inv01101:V003	[180'] [300']	×00: 7E AA	•	50 C2 C2
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAIN5 ameter List:	inv01101:V003 inv01102:V006	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG	inv01101:V003 inv01102:V006	[180'] [300']	10 00 00	•	50 C2 C2
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG e Window Start (Time Date):	inv01101:V003 inv01102:V006	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG	inv01101:V003 inv01102:V006	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG Window Start (Time Date): 22-15 07:50:00.000	inv01101:V003 inv01102:V006	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS meter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932,	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS meter List: 227 [LPFFLIGHT], ADT20028 [LPFFLIG 22 Window Start (Time Date): 22-15 08:40:00.000 c Window End (Time Date): 22-15 08:40:00.000 ber of samples (per parameter and 32932, 32932, 32932, 32932, 32932, 19	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 1 14 84 C2 1 16 98 82 1 14 88 CA 1 D2 D8 D2 0 00 00 F0
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS meter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG 2215 07:50:00.000 window End (Time Date): 22-15 08:40:00.000 window End (Time Date): 22-15 08:40:00.000 ber of samples (per parameter and 32932,32932,32932,32932,32932,119 ber of parameters:	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592	[180'] [300']	10 00 00	92 40 40 40 40 62 9E F4 6	5C C2 C2 1 14 84 C2 1 16 98 82 1 14 88 CA 1 D2 D8 D2 0 00 00 F0
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 2027 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:000 e Window End (Time Date): 202-15 09:40:000 e Window End (Time Date): 202-15 09:40:000 e Window End (Time Date): 202-15 09:40:000 e Window End (Time Date): 202-15 09:4000 e Window End (Time Date): 202-15 09:40000 e Window End (Time Date): 202-15 09:40000 e Window End (Time Date): 202-15 09:40000 e Window End (Time Date): 202-15 09:400000 e Window End (Time Date): 202-15 09:400000000000000000000000000000000000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 ,Min,Avg,StdDev	[180] [300] PFFLIGHT], ADT2003	e [LPFFLIGHT], ADT	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 6 # Numb 6 # Numb 6 # Numb	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT],ADT20028 [LPFFLIG 2215 07:50:00.000 window End (Time Date): 22-15 08:40:00.000 window End (Time Date): 22-15 08:40:00.000 ber of samples (per parameter and 32932,32932,32932,32932,32932,119 ber of parameters:	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00	[180] [300] PFFLIGHT], ADT2003	e [LPFFLIGHT], ADT	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS immeter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 ber of samples (per parameter and 32932, 32932, 32932, 32932, 32932, 32932, 19 ber of parameters: c, Unit, Description, Data, Type, Max, 027, m, DFA_PreProcSen_IsTm2X, DOUB 029, m, DFA_PreProcSen_IsTm2X, DOUB	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.00090,-0.00 LE,0.00090,-0.00 LE,0.00090,-0.00	[180] [300] DFFLIGHT], ADT2003	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS immeter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 ber of samples (per parameter and ,32932, 32932, 32932, 32932, 32932, 19 ber of parameters: e, Unit, Description, Data, Type, Max, 027, m, DFA_PreProcSen_IsTm2X, DOUB 029, m, DFA_PreProcSen_IsTm2Z, DOUB 030, rad, DFA_PreProcSen_IsTm2Z, DOUB	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.00990,-0.00 E,0.00990,-0.00 E,0.00990,-0.00 E,0.00990,-0.00	[180'] [300'] DFFLIGHT], ADT2003 PFFLIGHT], ADT2003 PE220, 0.000074, 0. 11427, -0.000140, 0 12045, -0.000268, 0 0.002056, 0.00589	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554 4,0.014172	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 32–15 07:50:00.000 e Window End (Time Date): 32–15 08:40:00.000 ber of samples (per parameter and ,32932, 3292, 32932, 3292, 3292, 3292, 3292, 3292, 3	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.0001495,-0.00 LE,0.0001495,-0.00 LE,0.000156,-0.00 D0UBLE,0.050149,- D0UBLE,0.052785,-	[180'] [300'] DFFLIGHT], ADT2003 DFFLIGHT], ADT2003 D4220, 0.000074, 0. 01427, -0.000148, 0 2045, -0.00268, 0 -0.02056, 0.00589 0.019259, 0.00449	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554 4,0.014172 8,0.014394	92 40 40 40 40 62 9E F4 6	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 ADT200 ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 227 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 22-15 07:50:00.000 e Window End (Time Date): 22-15 08:40:00.000 e Window End (Time Date): 22-15 08:40:00.000 e Window End (Time Date): 22-15 08:40:000 e Window End (Time Date): 22-15 08:40:000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 ,Min,Avg,StdDev LE,0.001495,-0.00 LE,0.000495,-0.00 LE,0.00096,-0.00 LE,0.000455,-0.00 D008LE,0.002785,- D008LE,0.002785,- D008LE,0.002265,-	[180] [300] DFFLIGHT], ADT2003 00220, 0. 000074, 0. 01427, -0. 000148, 0 02045, -0. 000268, 0 -0.022056, 0. 00559 -0.019259, 0. 00449 -0.011945, -0. 0005	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554 4,0.014172 8,0.014394 68,0.002453	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT]	5C C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 00 BE
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 # ADT200 # ADT200 # ADT200 # ADT200 # ADT200 # ADT200	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 2027 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:000 e Window End (Time Date): 202-15 08:40:0000 e Window End (Time Date): 202-15	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev E,0.001495,-0.00 E,0.0009E,0.00156,-0.00 E,0.0008E,0.002149,- 0008E,0.002785,- 0008E,0.002265,- 0008E,0.002265,-	[180] [300] DFFLIGHT], ADT2003 00220, 0.000074, 0. 01427, -0.000148, 0 02045, -0.000268, 0 0.002050, 0.00459 0.012559, 0.00449 0.011945, -0.0005 ADT20029 [LPFFLI	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000235 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT],ADT20032 [LPFFLIGHT]	SC C2 C2 1 14 84 C2 1 16 98 82 1 14 88 CA 1 2 D8 D2 0 00 00 F0 0 3 46 02 1 77 E0 75 1 41 80 8F 0 00 00 00 0 00 00 0 00 2B BE
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 Numb 32932, # Numb 6 ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 # DATE 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and 32932, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292,	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.00156,-0.00 LE,0.00156,-0.00 DUBLE,0.050149,- DOUBLE,0.050149,- DOUBLE,0.062785,- DOUBLE,0.002785,- DOUBLE,0.0	[180 ⁷] [300 ⁷] [30	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000356 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000	92 40 40 40 40 62 9E F4 6 20031 (LPFFLIGHT), ADT20032 (LPFFLIGHT) FFLIGHT), ADT20031 [LPFFLIGHT], ADT20032 [LPFI 597788274609, 0.0001205437170791, 0.0000155399	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 2B BE
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 Numb 32932, # Numb 6 ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 # DATE 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and 32932, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292, 3292,	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.00156,-0.00 LE,0.00156,-0.00 DUBLE,0.050149,- DOUBLE,0.050149,- DOUBLE,0.062785,- DOUBLE,0.002785,- DOUBLE,0.0	[180 ⁷] [300 ⁷] [30	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000356 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT],ADT20032 [LPFFLIGHT]	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 2B BE
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 ADT200 AD	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS ameter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 ber of samples (per parameter and 32932, 3292, 3292, 3292, 32	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.001495,-0.00 LE,0.00156,-0.00 D0UBLE,0.050149,- D0UBLE,0.062785,- D0UBLE,0.002265,- 0008LE,0.002265,- 0008LE,0.00020288 02799,0.00000285	[180'] [300'] DFFFLIGHT], ADT2003 PFFLIGHT], ADT200	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000	92 40 40 40 40 62 9E F4 6 20031 (LPFFLIGHT), ADT20032 (LPFFLIGHT) FFLIGHT), ADT20031 [LPFFLIGHT], ADT20032 [LPFI 597788274609, 0.0001205437170791, 0.0000155399	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 2B BE FLIGHT] 2898855
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 # DATE 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS ameter List: 2027 (LPFFLIGHT),ADT200288 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:000 e of samples (per parameter and 32932,32932,32932,32932,32932,11 ber of parameters: e,Unit,Description,Data,Type,Max, 2027,m,DFA_PreProcSen_IsTm2X,DOUB 2029,m,DFA_PreProcSen_IsTm2X,DOUB 2029,m,DFA_PreProcSen_IsTm2X,DOUB 2029,m,DFA_PreProcSen_IsTm2Z,DOUB 300,rad,DFA_PreProcSen_IsTm2Zta, 302,rad,DFA_PreProcSen_IsTm2Zta, 3032,rad,DFA_PreProcSen_IsTm2Z,D0UBI 304,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PreProcSen_IsTm2Z,D0UBI 305,rad,DFA_PREPROSE,0020020000000000000000000000000000000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 07592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.001495,-0.00 LE,0.001495,-0.00 DUBLE,0.0056,-0.00 DUBLE,0.0056,-0.00 DUBLE,0.002785,- D0UBLE,0.002785,- D0UBLE,0.002785,- D0UBLE,0.002265,- 000000000000000000000000000000000000	[180'] [300'] DFFLIGHT], ADT2003 DFFLIGHT], ADT2003 DFFLIGHT], ADT2003 D1427, -0.000148, 0 2045, -0.00268, 0 200256, 0.00258 0.019259, 0.00449 -0.011945, -0.0005 ADT20029 [LPFFLI 3333934, 0.000000 56839236, 0.000000	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000336 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2183940425,0.0000	92 40 40 40 40 62 9E F4 6 PP PP F0 60 60 60 PP 70 P 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0.0001205437170791, 0.0000154500	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 00 BE FLIGHT] 2005377
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 Numb 32932, # Numb 6 ADT200 ADT20 ADT	New SysID - Drag Free injections New SysID - Suspension Injections orted Parameter(s) from GRAINS ameter List: 027 (LPFFLIGHT), ADT20028 (LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:000 ber of samples (per parameter and 32932,	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.00196,-0.00 LE,0.00196,-0.00 LE,0.002156,-0.00 DUBLE,0.002165,- D0UBLE,0.002165,- D0UBLE,0.002165,- D0UBLE,0.0020265 S2209,0.000002085 S2209,0.000002085 S2209,0.000002085	[180 ⁷] [300 ⁷] [3	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 000235 .000386 .000554 4,0.014394 68,0.02453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2165005898,0.0000 2058469204,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT],ADT20032 [LPFFLIGHT] FFLIGHT],ADT20031 [LPFFLIGHT],ADT20032 [LPFI 597788274609,0.0001205437170791,0.0000155390 588061967621,0.0001221921795753,0.0000154500 599574523458,0.0001199095090284,0.0000155955	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 777 E0 75 41 80 8F 000 00 00 00 00 00 00 00 00 00 2B BE FLIGHT] 2898355 2754396 2905377 3532040
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 # Name 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS ameter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and 32932, 359, 0.00000029600000000000000000000000000000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.00195,-0.00 LE,0.00195,-0.00 LE,0.00156,-0.00 DUBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.003265,- 0008LE,0.000165,-0.00 D008LE,0.00002055 52209,0.000002085 52209,0.000002085 52209,0.000002085	[180'] [300'] DFFFLIGHT], ADT2003 PFFLIGHT], ADT2003 00228, 0.000074, 0. 01427, -0.000148, 0 02045, -0.000268, 0 0.002056, 0.002589 0.01945, -0.000268 ADT20029 [LPFFLI 13333934, 0.000000 03859780, 0.000000 03859780, 0.000000 03859780, 0.000000 03859780, 0.000000	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 000235 .000386 .000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2165005898,0.0000 2058469284,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT],ADT20032 [LPFFLIGHT] FFLIGHT],ADT20031 [LPFFLIGHT],ADT20032 [LPFF 597788274609,0.0001205437170791,0.0000155399 588061967621,0.0001221921795753,0.0000154500 599574523458,0.0001199095090284,0.0000154500 595608294568,0.0001208669669671,0.0000146780	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 00 BE SLIGHT] S888855 9754396 2905377 3532040 8773513
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT20 ADT	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS imeter List: 2027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 08:40:00.000 e of parameters: 2020, apple of parameters: 2020, m, DFA_PreProcSen_IsTm2X, DOUBI 2020, m, DFA_PreProcSen_IsTm2Z, DOUBI 2021, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2022, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2023, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2024, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2025, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2026, rad, DFA_PreProcSen_IsTm2Z, DOUBI 2027, rad, DFA_PRE, DOUBI	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 ,Min,Avg,StdDev LE,0.004990,-0.00 LE,0.004990,-0.00 LE,0.00990,-0.00 LE,0.00990,-0.00 LE,0.00990,-0.00 LE,0.00990,-0.00 DUBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.050149,- D0UBLE,0.062785,- 000BLE,0.00002085 52209,0.000002085 52209,0.000002085 52209,0.000002085 52209,0.000002085	[180 ⁷] [300 ⁷] DFFLIGHT], ADT2003 PFFLIGHT], ADT2003 PFFLIGHT], ADT2003 PFFLIGHT], ADT2003 PFFLIGHT], ADT2003 PFFLIGHT], ADT2003 P00256, 0.00589 -0.019259, 0.00449 -0.019259, 0.00449 -0.019259, 0.00449 -0.019259, 0.00000 03359780, 0.000000 03359780, 0.000000	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 000235 000386 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2058469204,0.0000 2058469204,0.0000 2077753853,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0.0001205437170791, 0.000015539 588061967621, 0.0001221921795753, 0.000015540 599574523458, 0.0001226996277295, 0.0000155443	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 777 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 00 BE FLIGHT] 0898855 0754396 2905377 3532040 3773513 3226110
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Time 2016-0 # Numb 32932, # Numb 6 ADT200 ADT00 ADT200 ADT0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS ameter List: 2027 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 e Window End (Time Date): 202-15 07:50:00.000 203, m,DFA_PreProcSen_IsTm2X,DOUB 203, m,DFA_PreProcSen_IsTm2Y,DOUB 203, m,DFA_PreProcSen_IsTm2Y,DOUB 203, m,DFA_PreProcSen_IsTm2The,D 202, m,DFA_PREPROSS, 0.0000000296055 202, m,DFA_PREPROSS, 0.000000296055 202, m,DFA_PREPROSS, 0.0000000296055 202, m,DFA_PREPROSS, 0.000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.001495,-0.00 LE,0.001495,-0.00 LE,0.00196,-0.00 LE,0.00205,-0.00 DUBLE,0.052149,- D0UBLE,0.052149,- D0UBLE,0.0020285 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085 92799,0.000002085	[180 ⁷] [300 ⁷] [3	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 000355 000386 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2165005898,0.0000 2125821951,0.0000 2077753853,0.0000 1980862259,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0.0001205437170791, 0.0000155399 588061967621, 0.0001221921795753, 0.0000154500 599574523458, 0.0001206095090284, 0.0000155443 5995608294568, 0.0001226996277295, 0.0000155443 580584044225, 0.0001226996277295, 0.0000155443	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 777 E0 75 41 80 8F 000 00 00 00 00 00 00 00 00 00 2B BE FLIGHT] 2898355 2754396 2905377 3532040 3694573
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS ameter List: 027 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 02-15 07:50:00.000 e Window End (Time Date): 02-15 08:40:00.000 ber of samples (per parameter and 32932, 329	inv01101:V003 inv01102:V006	[180 ⁷] [300 ⁷] [30	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 2058469204,0.0000 2058469204,0.0000 2077753853,0.0000 1980862259,0.0000 1894069252,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0.0001221921795753, 0.0000155560 599574523458, 0.0001221921795753, 0.0000155560 5995608294568, 0.0001226696669671, 0.0000155544 580584044225, 0.0001226996277295, 0.000015544 581938559341, 0.0001221293831571, 0.0000163600	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 2B BE SUBSS 0754396 2905377 3532040 3773513 3226665
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 ADT200 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS imeter List: 227 [LPFFLIGHT], ADT20028 [LPFFLIG e Window Start (Time Date): 22-15 07:50:00.000 e Window End (Time Date): 22-15 08:40:00.000 e Window End (Time Date): 22-15 08:40:00.000 ber of samples (per parameter and ,32932, 3292, 3292	inv01101:V003 inv01102:V006	[180 ⁷] [300 ⁷] [3	0 (LPFFLIGHT), ADT 0 (LPFFLIGHT), ADT 0 (LPFFLIGHT), ADT 0 000386 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 (LP 2126240847, 0.0000 2183940425, 0.0000 215505898, 0.0000 2058469204, 0.0000 2057753853, 0.0000 1980862259, 0.0000 1980862259, 0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0.0001205437170791, 0.0000155391 588061967621, 0.0001221921795753, 0.0000154501 599574523458, 0.00012205090284, 0.0000155953 595608294568, 0.0001226996277295, 0.0000155443 581938559341, 0.0001226996277295, 0.0000155443 581651233178, 0.0001221293831571, 0.0000159963	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 00 00 00 2B BE SUBSS 0754396 2965377 3532040 3694573 3256665 3494455
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS imeter List: 2027 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 ber of samples (per parameter and 32932,32932,32932,32932,32932,32932,19 ber of parameters: e,Unit,Description,Data,Type,Max, 2027,m,DFA_PreProcSen_IsTm2X,DOUB 2029,m,DFA_PreProcSen_IsTm2Y,DOUB 2030,m,DFA_PreProcSen_IsTm2Y,DOUB 2030,rad,DFA_PreProcSen_IsTm2The,D 2031,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 202-15 07:50:00.155,0.000000296065 202-15 07:50:00.555,0.000000296065 202-15 07:50:00.455,0.000000296065 202-15 07:50:00.655,0.000000296065 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.0000000290055 202-15 07:50:00.655,0.000000290055 202-15 07:50:00.655,0.000000290055 202-15 07:50:00.852,0.000000290055 202-15 07:50:00.855,0.000000290055 202-15 07:50:00.855,0.0000000290055 202-15 07:50:00.855,0.00000000000000000000000000000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 DUBLE,0.0024785,- 0008LE,0.0024785,- 0008LE,0.00202055 S2209,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002084 93030,0.000002084 93030,0.000002084 93030,0.000002084 93030,0.000002094 12081,0.000002094	[180 ⁷] [300 ⁷] [3	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 00036 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 21650058988,0.0000 2058469204,0.0000 1980862259,0.0000 1980862259,0.0000 2000509882,0.0000 2000509882,0.0000	92 40 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLICHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFF 597788274609, 0. 0001205437170791, 0. 0000155399 588061967621, 0. 0001221921795753, 0. 0000154500 599574523458, 0. 00011205096284, 0. 0000154505 595608294568, 0. 0001226996277295, 0. 0000156780 5880584044225, 0. 0001226996277295, 0. 0000163600 5881651233178, 0. 0001221293831571, 0. 0000163600 5885640263125, 0. 0001221293831571, 0. 0000163600 5885640263125, 0. 0001206772354359, 0. 00000163600 5885640263125, 0. 0001206772354359, 0. 0000163600 5885269332744, 0. 0001199734140114, 0. 0000161050	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 777 E0 75 41 80 8F 000 00 00 00 00 00 00 2B BE STIGHT] S889855 S754396 2905377 S32040 3773513 3226110 3694573 3256665 3494455
02:30 > 05:30	- ,	05:30 10:30 # Expo # Para ADT200 # Time 2016-0 # Numb 32932, # Numb 6 # Name ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 ADT200 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0 2016-0	New SysID - Drag Free injections New SysID - Suspension Injections Orted Parameter(s) from GRAINS imeter List: 2027 (LPFFLIGHT),ADT20028 (LPFFLIG e Window Start (Time Date): 202-15 07:50:00.000 e Window End (Time Date): 202-15 08:40:00.000 ber of samples (per parameter and 32932,32932,32932,32932,32932,32932,19 ber of parameters: e,Unit,Description,Data,Type,Max, 2027,m,DFA_PreProcSen_IsTm2X,DOUB 2029,m,DFA_PreProcSen_IsTm2Y,DOUB 2030,m,DFA_PreProcSen_IsTm2Y,DOUB 2030,rad,DFA_PreProcSen_IsTm2The,D 2031,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 2032,rad,DFA_PreProcSen_IsTm2The,D 202-15 07:50:00.155,0.000000296065 202-15 07:50:00.555,0.000000296065 202-15 07:50:00.455,0.000000296065 202-15 07:50:00.655,0.000000296065 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.000000290005 202-15 07:50:00.655,0.0000000290055 202-15 07:50:00.655,0.000000290055 202-15 07:50:00.655,0.000000290055 202-15 07:50:00.855,0.000000290055 202-15 07:50:00.855,0.000000290055 202-15 07:50:00.855,0.0000000290055 202-15 07:50:00.855,0.00000000000000000000000000000	inv01101:V003 inv01102:V006 GHT],ADT20029 [LP d total): 97592 Min,Avg,StdDev LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 LE,0.000495,-0.00 DUBLE,0.0024785,- 0008LE,0.0024785,- 0008LE,0.00202055 S2209,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002088 92799,0.000002084 93030,0.000002084 93030,0.000002084 93030,0.000002084 93030,0.000002094 12081,0.000002094	[180 ⁷] [300 ⁷] [3	0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 [LPFFLIGHT], ADT 0 00036 000554 4,0.014172 8,0.014394 68,0.002453 GHT], ADT20030 [LP 2126240847,0.0000 2183940425,0.0000 21650058988,0.0000 2058469204,0.0000 1980862259,0.0000 1980862259,0.0000 2000509882,0.0000 2000509882,0.0000	92 40 40 40 62 9E F4 6 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] 20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] FFLIGHT], ADT20031 [LPFFLIGHT], ADT20032 [LPFFLIGHT] 597788274609, 0.0001205437170791, 0.0000154500 599574523458, 0.0001221921795753, 0.0000154500 599574523458, 0.0001206095090284, 0.0000155953 595608294568, 0.000120609609671, 0.0000160503 580584044225, 0.0001226996277295, 0.0000155443 581938559341, 0.0001226996277295, 0.0000155443 581051233178, 0.000122192139331571, 0.0000163600 585640263125, 0.0001206712354359, 0.0000159963 582569332744, 0.0001199734140114, 0.0000161050 585269332744, 0.0001199734140114, 0.0000161050	SC C2 C2 14 84 C2 16 98 82 14 88 CA D2 D8 D2 00 00 F0 03 46 02 77 E0 75 41 80 8F 00 00 00 00 00 00 00 2B BE Prigon 2905377 2532040 27754396 2905377 2532040 2775513 2256665 2904573 2256665 290455

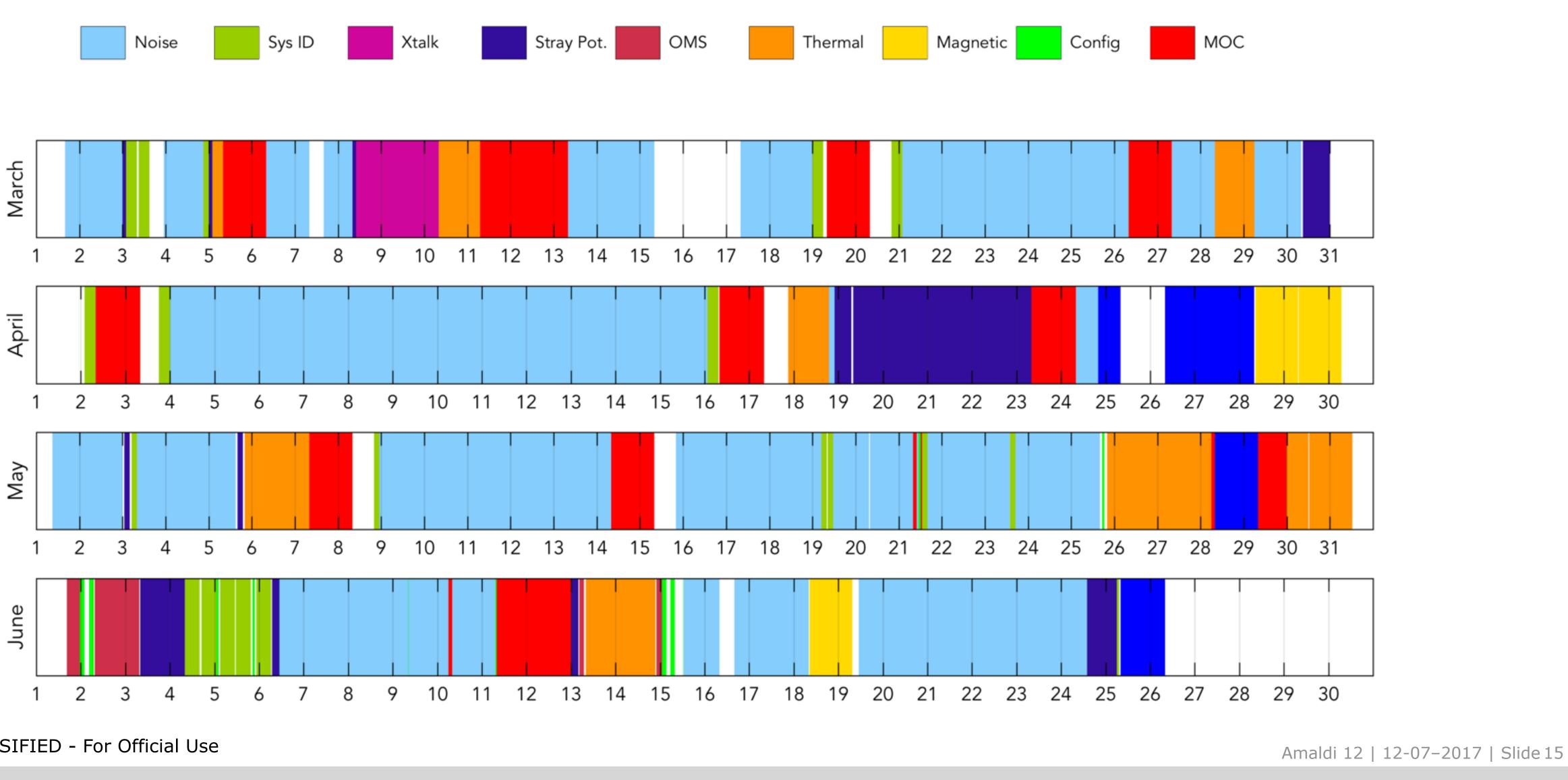
European Space Agency

*

•

)7-2017 | Slide 14

Nominal Phase



ESA UNCLASSIFIED - For Official Use

- - -

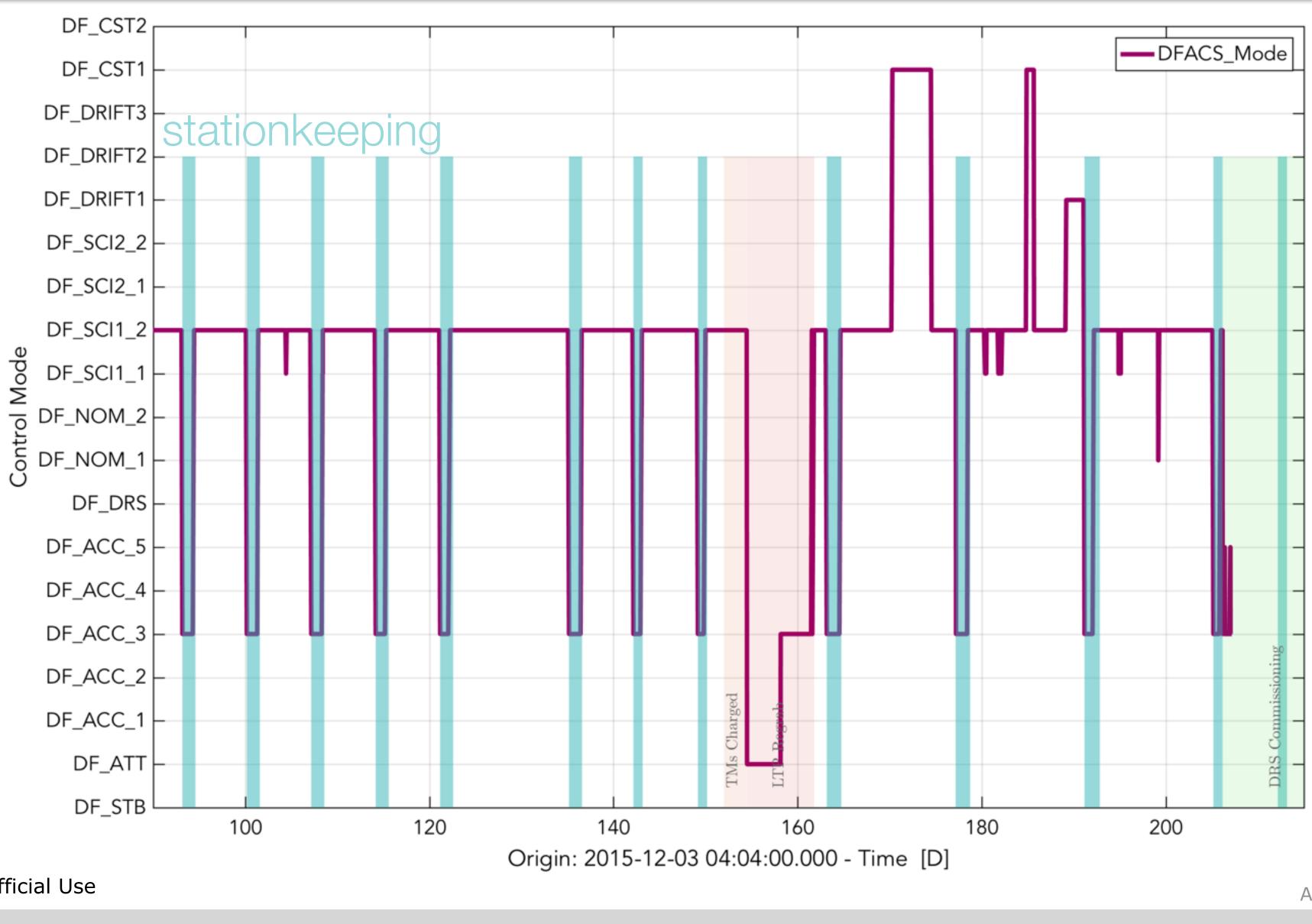


European Space Agency

+

*

Duty Cycle during nominal science phase



ESA UNCLASSIFIED - For Official Use





Amaldi 12 | 12-07-2017 | Slide 16

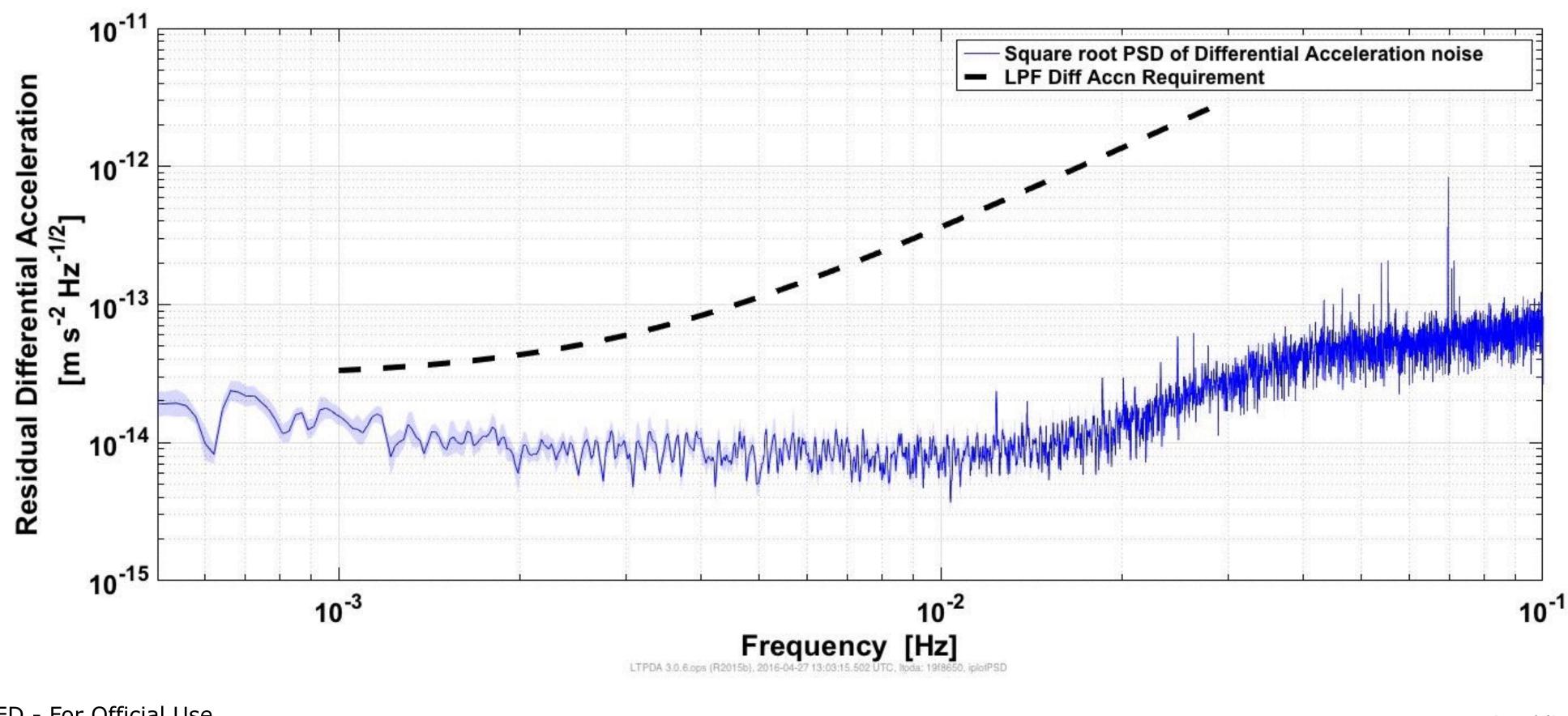
*

+

Differential Acceleration

The differential acceleration between the test masses (known as "delta-g") is the primary performance requirement of the mission...

...and was met during commissioning!



ESA UNCLASSIFIED - For Official Use

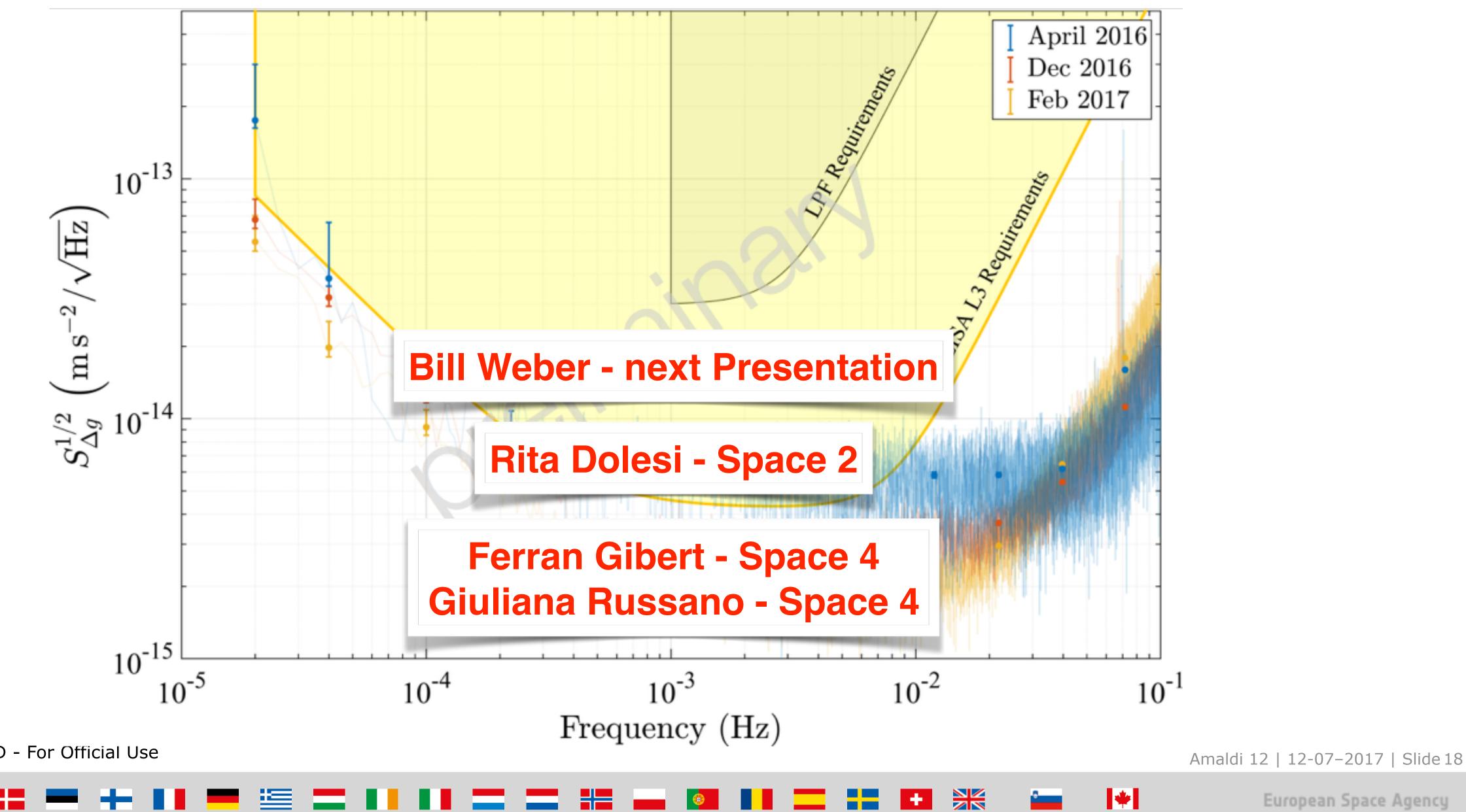


Amaldi 12 | 12-07-2017 | Slide 17

*

-

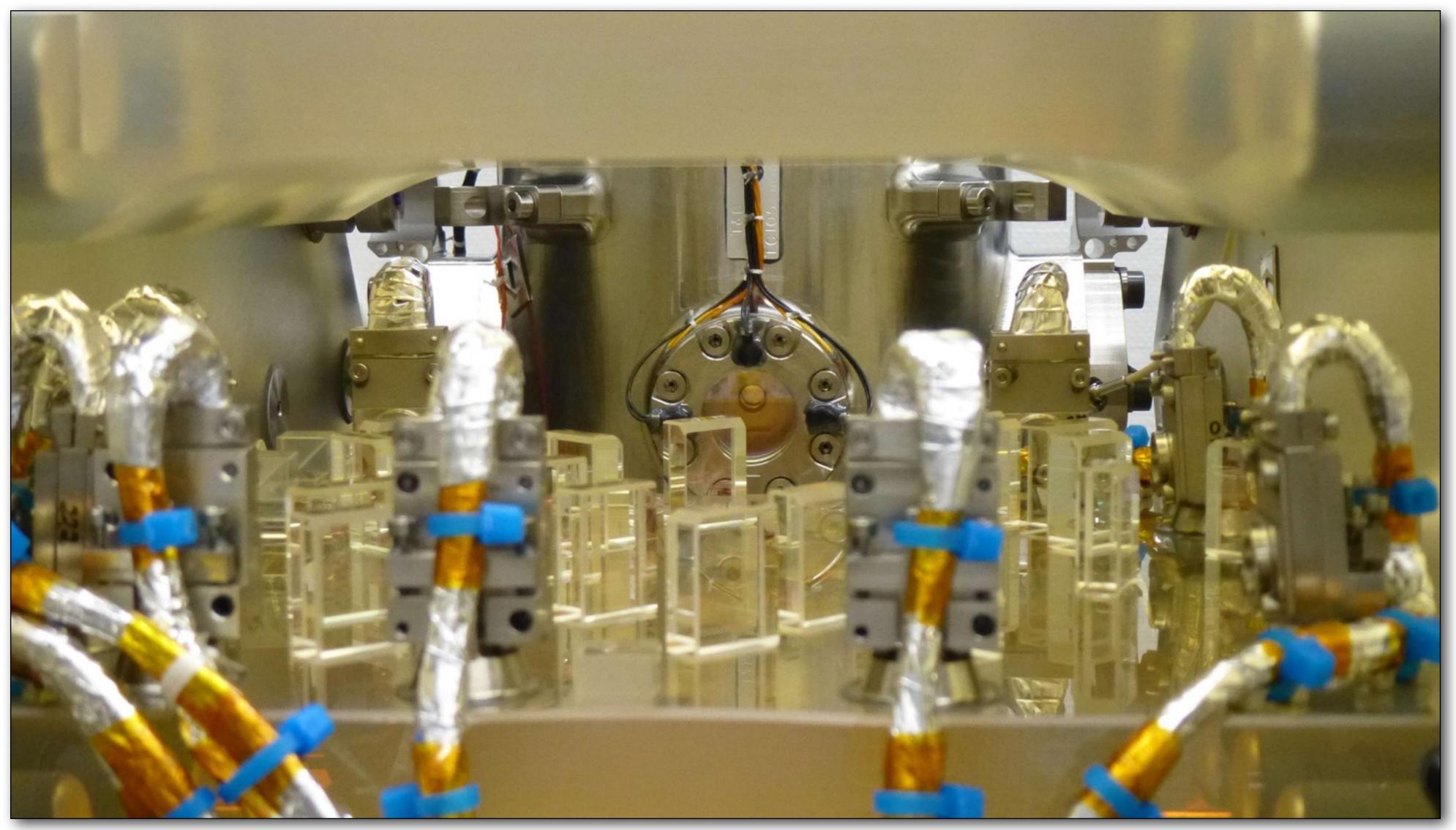
Latest performance...it keeps improving!



ESA UNCLASSIFIED - For Official Use



Optical Metrology System



ESA UNCLASSIFIED - For Official Use





Amaldi 12 | 12-07-2017 | Slide 19

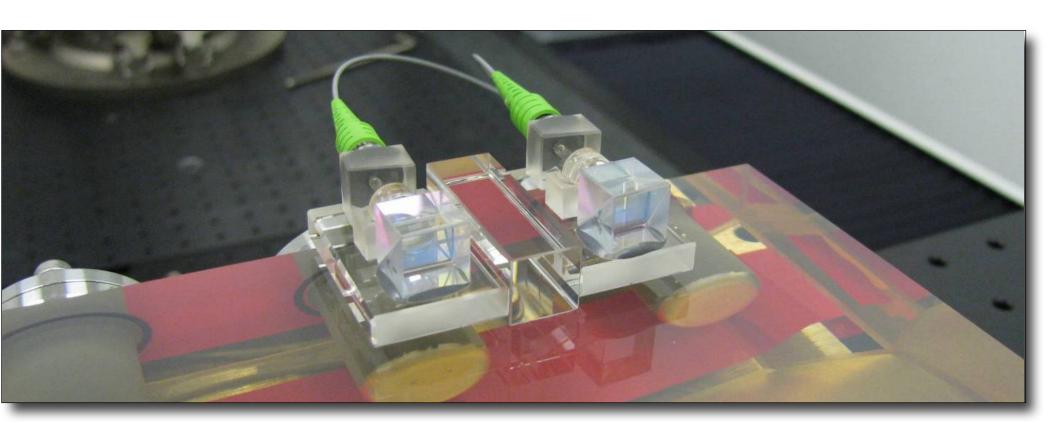




*

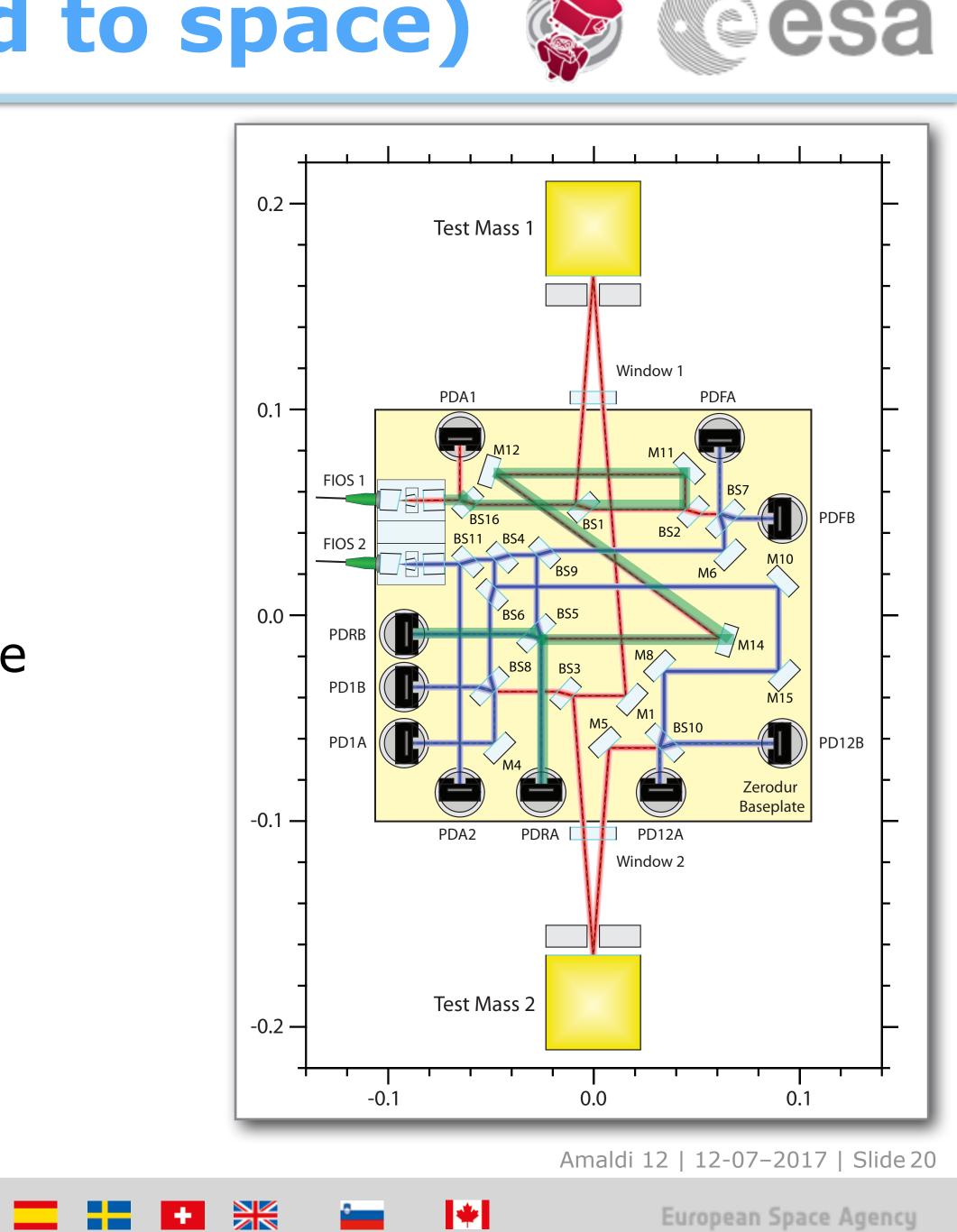
Beam alignment (from ground to space)

- ©One major worry was OMS alignment change from ground to space
- Any distortion of the optical bench shows up as large misalignment due to lever arm of optical path on bench
- © Optical bench alignment can be measured using the fixed interferometers
 - Reference ifo measurement beam is most sensitive to bench distortion



ESA UNCLASSIFIED - For Official Use





Alignment from ground to space

[um]			Flight	IABG	UGL	Flight - UGL	IABG - UGL	Flight - IABG	[um]			Flight	IABG	UGL	Flight - UGL	IABG - UGL	Flight - IABG
X 1		x	34	35				-1			x	12	18				-6
	A	у	-353	-343				-10		A	у	-3	-7				4
	в	x	13	13				0	X1	_	x	-5	-4				-1
		У	-350	-336				-14		В	У	-9	-16				7
X12	A	x	80	84				-4		A	x	18	13				5
		У	-389	-400				11	¥10		у	-23	-23				0
	в	x	-74	-76				2	X12	в	x	8	11				-3
		у	-390	-394				4			у	16	16				0
XF	A	x	21	21	21	0	0	0		A	x	26	19	21	5	-2	7
		У	-40	-35	-32	-8	-3	-5	VE		у	-35	-35	-29	-6	-6	0
	в	x	13	9	6	7	3	4	XF	в	x	7	11	8	-1	3	-4
		У	-25	-20	-15	-10	-5	-5			У	-19	-20	-13	-6	-7	1
XR	A	x	7	9	6	1	3	-2	XR	A	x	-8	-11	-13	5	2	3
		у	-29	-15	-6	-23	-9	-14			у	-10	-12	-6	-4	-6	2
	в	x	43	36	35	8	1	7		в	x	60	59	58	2	1	1
		у	70	79	83	-13	-4	-9			у	89	83	89	0	-6	6

Measurement Beam

ESA UNCLASSIFIED - For Official Use





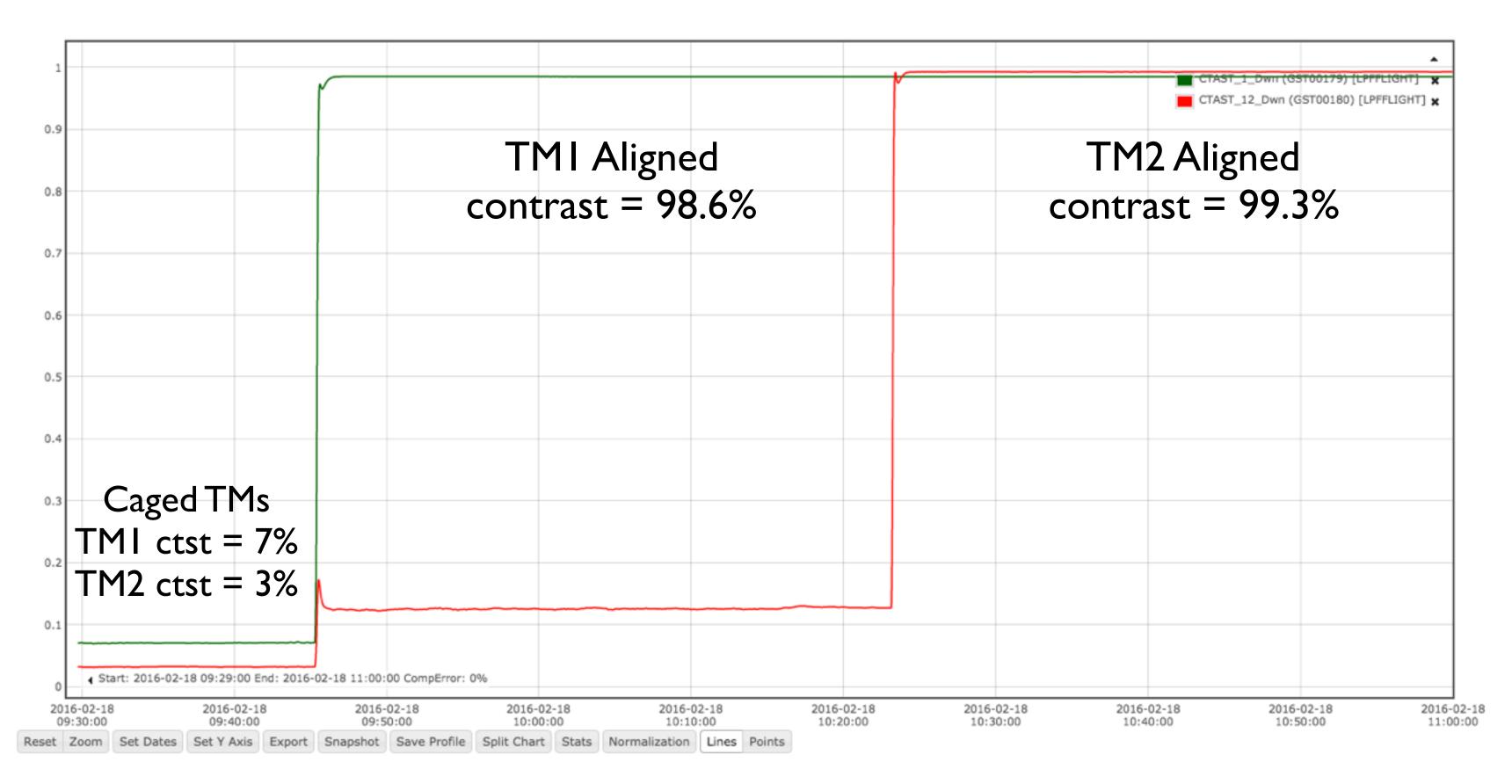
Reference Beam

Amaldi 12 | 12-07-2017 | Slide 21

Interferometer alignment

© Following TM release, we could align the free-floating test masses using the electrostatic actuation

- Contrast increased from ~few % to close to 100%
 - Best ground measured alignment was ~92%



ESA UNCLASSIFIED - For Official Use



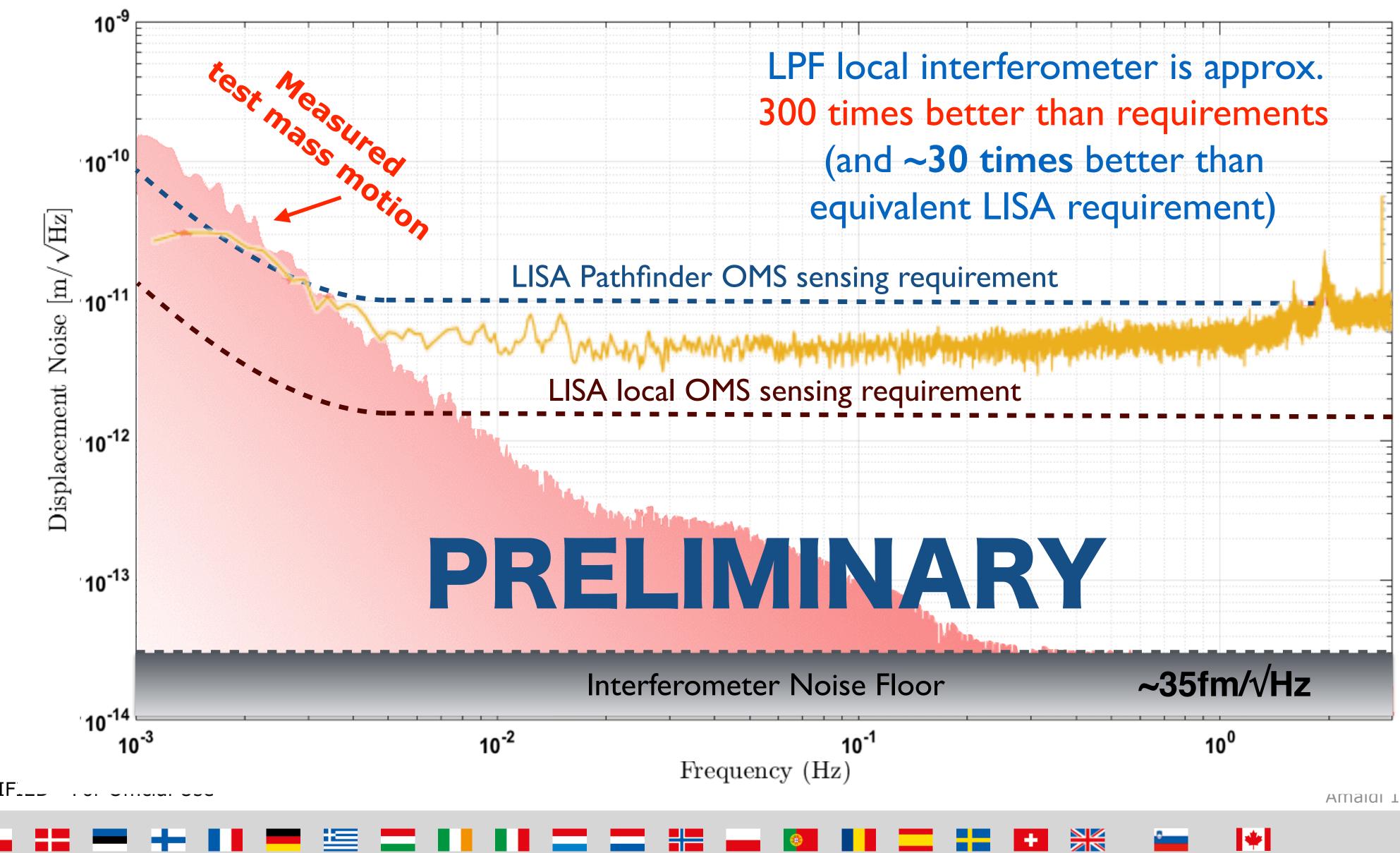


Amaldi 12 | 12-07-2017 | Slide 22

•



Performance: On-Orbit results

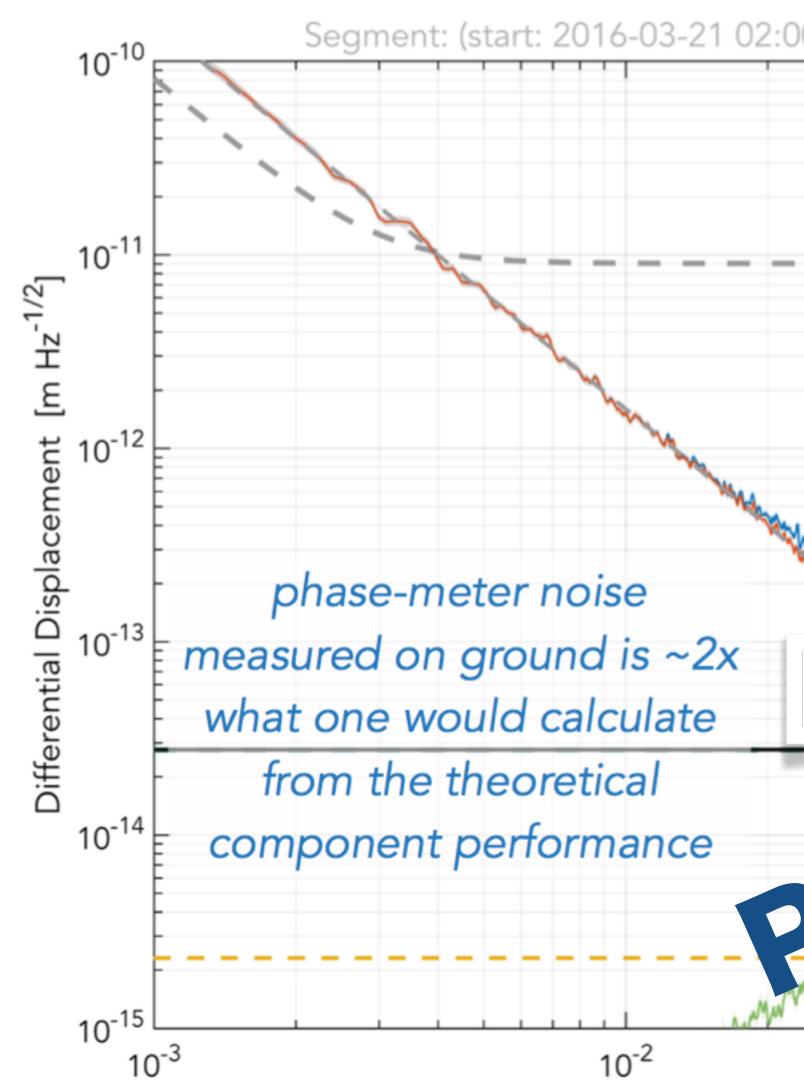


ESA UNCLASSIF____



Amaidi 12 | 12-07-2017 | Slide 23

Noise Budget



ESA UNCLASSIFIED - For Official Use





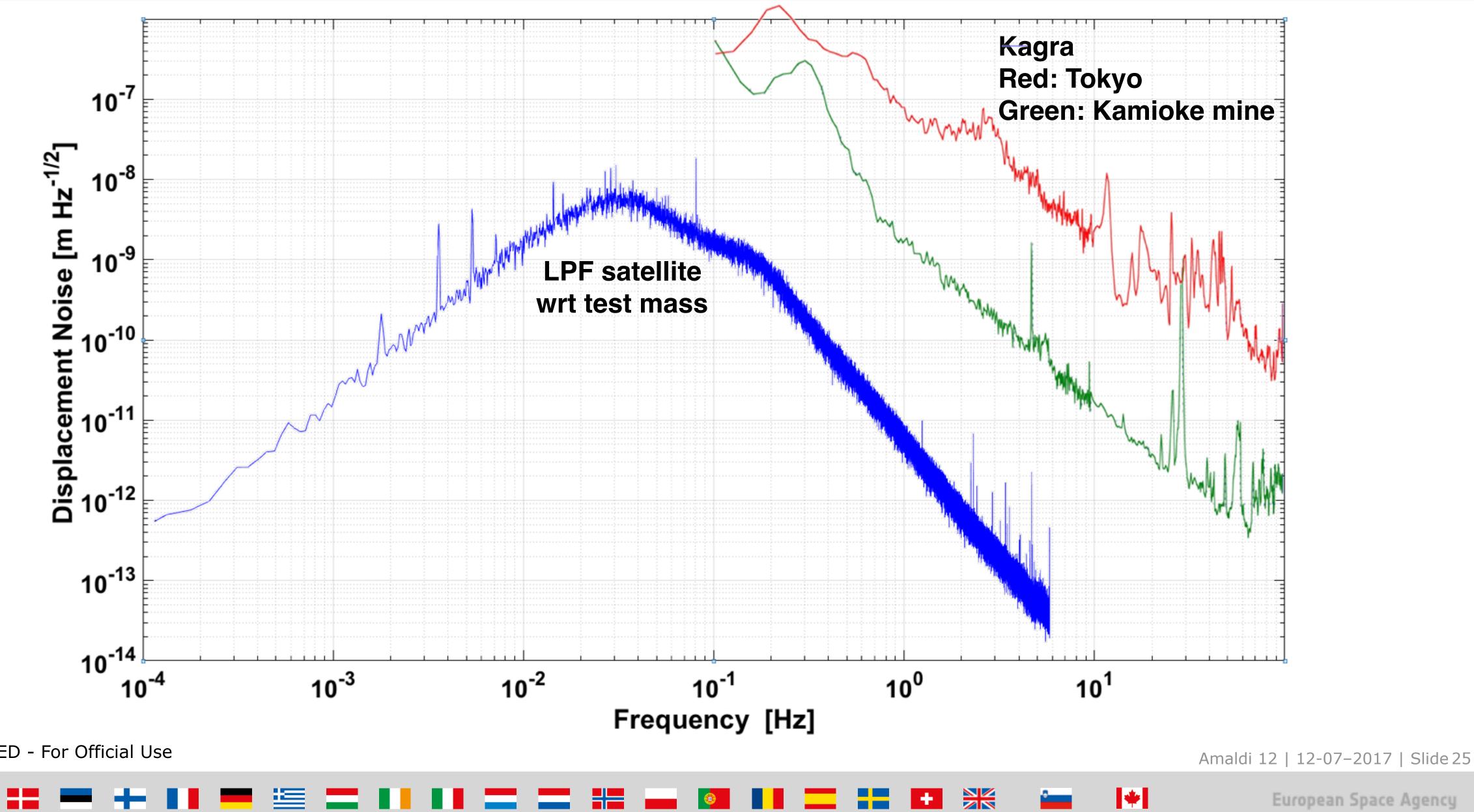
Segment: (start: 2016-03-21 02:00:00.090 UTC end: 2016-03-26 07:59:45.090 UTC) **OMS** Requirement -X12 -X12 - corrected for SC jitter **Frequency Noise** TM Motion from residual gas -Shot noise Total PM Noise (ground measurement) Total OMS Noise -Total Noise phase-meter noise measured on ground is around 650 nr - ()r per Sarah Paczkowski - Space 3 10⁰ 10⁻¹ Frequency [Hz]

+

Amaldi 12 | 12-07-2017 | Slide 24

*

Why so good?....space is quiet!



ESA UNCLASSIFIED - For Official Use



LPF: An international success

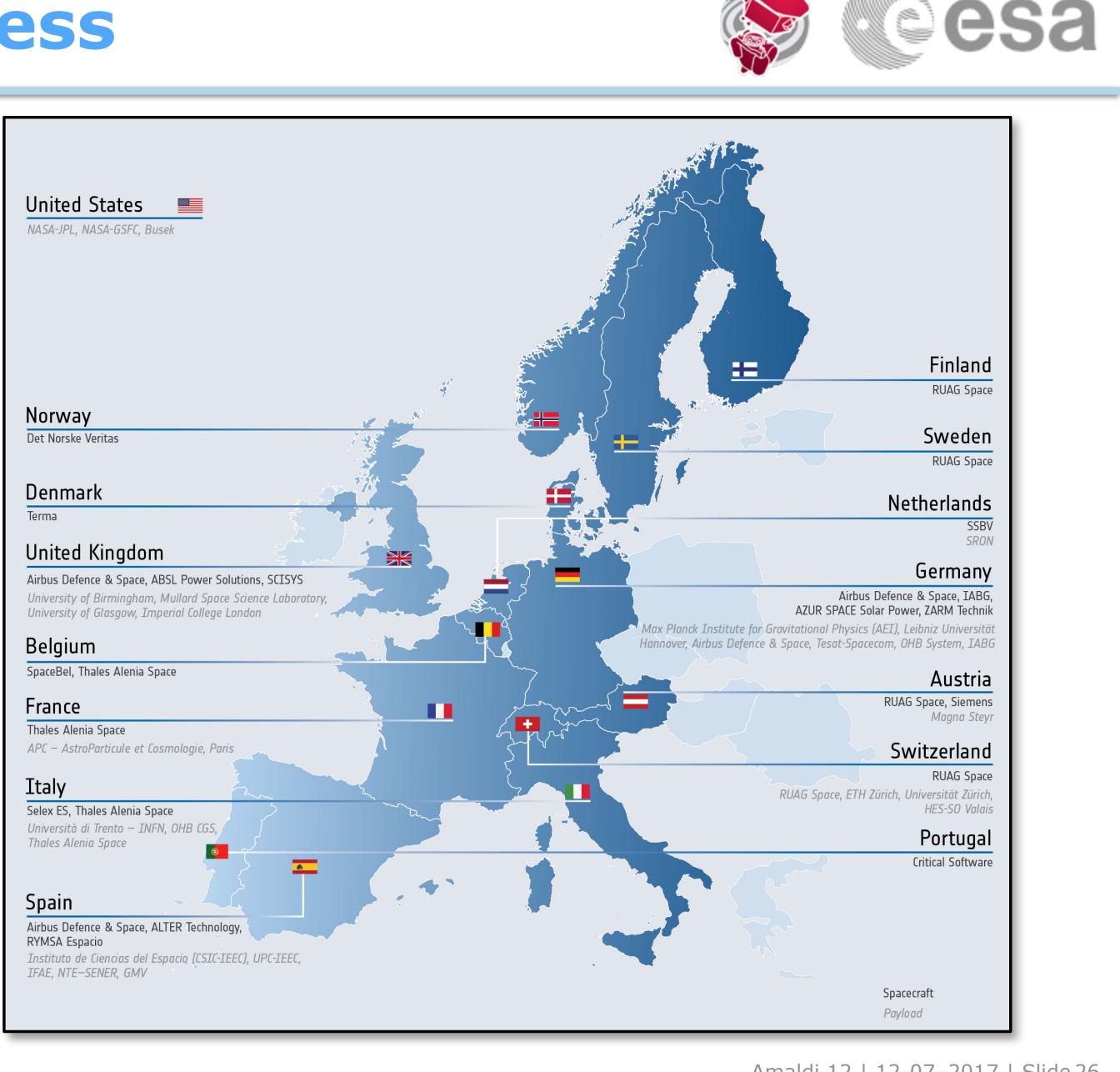
- ©LISA Pathfinder is an international endeavour
 - More than 40 companies and institutes
 - From 14 European countries and the USA

ESA UNCLASSIFIED - For Official Use









*

Amaldi 12 | 12-07-2017 | Slide 26

Conclusions

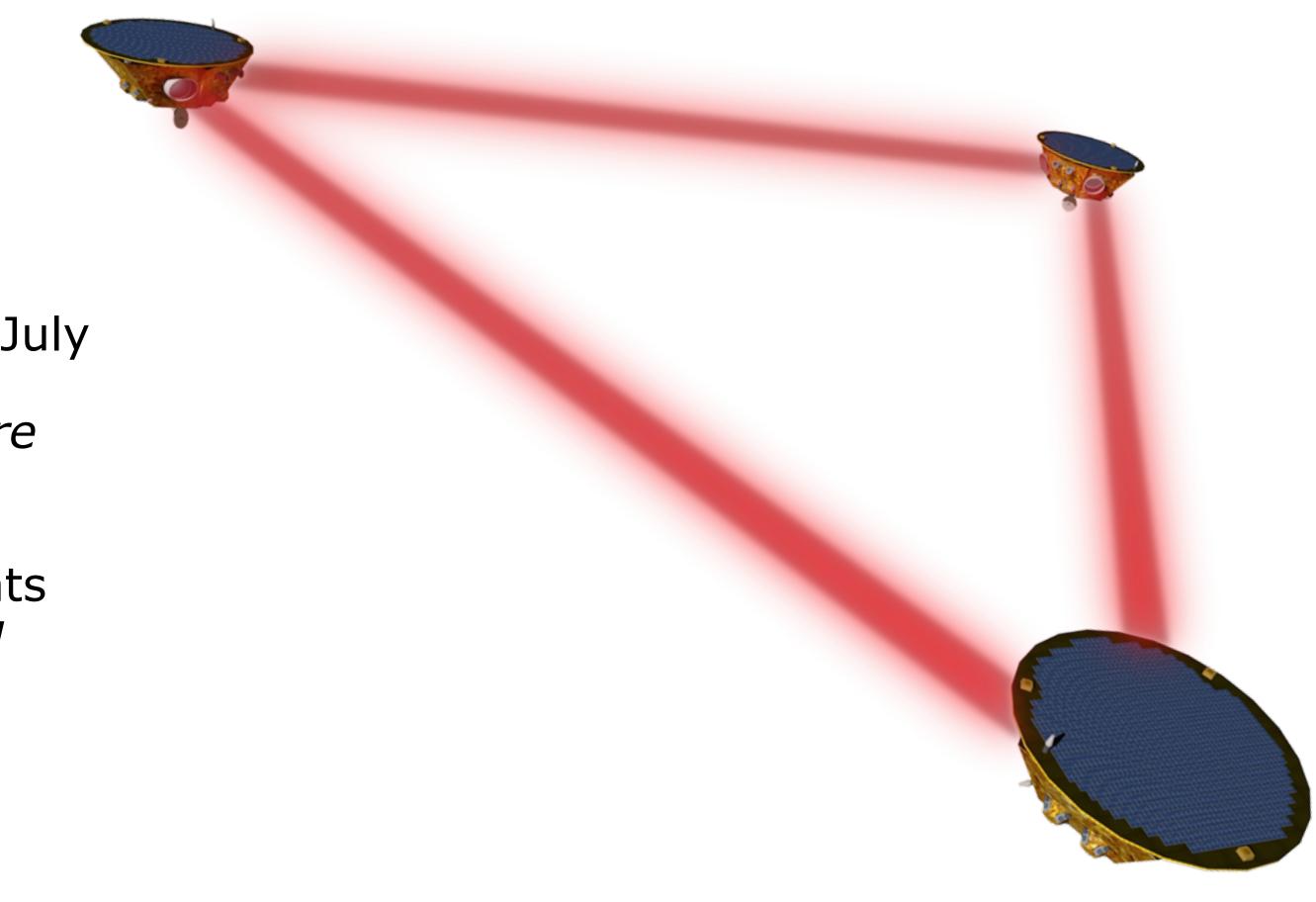
- Control LISA Pathfinder is the first step in the observation of gravitational waves from space
- © Successfully launched on 3 December 2015
- Mission operations lasted 16 months
 - End of Science Ops: 30 June 2017
- Final telecommand to be sent next week on 18 July
- All system performance requirements met before science operations began
- We have met the LISA performance requirements over the full LISA measurement bandwidth goal

Next step....LISA!

ESA UNCLASSIFIED - For Official Use







Amaldi 12 | 12-07-2017 | Slide 27



*



Thank you



