The following table includes a complete list of M&O core activities budgeted under this NSF M&O proposal, sorted by WBS, labor category, institution, name and task. The detailed bottom-up budget was developed based on the actual experience during the past twelve years of the IceCube M&O.

WBS Level 2	WBS Level 3	Institution	Labor Category	Names	Task	Year1 (FTE)	Year2 (FTE)	Year3 (FTE)	Year4 (FTE)	Year5 (FTE)
2.1 Program Coordination	2.1.1 Administration	UW	Faculty	HALZEN, FRANCIS	Principal Investigator	0.38	0.38	0.38	0.38	0.38
				HANSON, KAEL	Director of Operations	0.60	0.60	0.60	0.60	0.60
				KARLE, ALBRECHT	Associate Director for Science and Instrumentation	0.38	0.38	0.38	0.38	0.38
			Scientist	DESIATI, PAOLO	IceCube Coordination Committee Chair	0.75	0.75	0.75	0.75	0.75
			Academic Staff	VAKHNINA, CATHERINE	IceCube Resource Coordinator	0.50	0.50	0.50	0.50	0.50
				WITT, BARBARA	Accountant	0.15	0.15	0.15	0.15	0.15
				CHORLTON, TINA	HR Manager	0.15	0.15	0.15	0.15	0.15
		UMD	Faculty	SULLIVAN, GREG	Supervise UMD effort	0.02	0.02	0.02	0.02	0.02
			Academic Staff	ZHANG, YU	Admin support	0.04	0.04	0.04	0.04	0.04
		UD	Scientist	TILAV, SERAP	Supervise UD effort	0.10	0.10	0.10	0.10	0.10
		LBNL	Faculty	KLEIN, SPENCER	Supervise LBNL effort	0.05	0.05	0.05	0.05	0.05
	2.1.1 Administration Total					**3.13**	**3.13**	**3.13**	**3.13**	**3.13**
	2.1.2 Engineering and R&D Support	UW	Scientist	DUVERNOIS, MICHAEL	South Pole & Northern test site instrumentation, South Pole field work	0.33	0.33	0.33	0.33	0.33
			Manager	HAUGEN, JAMES	Engineering Support: logistics, northern hemisphere testing, & vendor management, contractor POC	0.05	0.05	0.05	0.05	0.05
			Engineer	MEURES, THOMAS	Engineering Support: IceCube Lab Summer operations, cabling, power systems, & instrumentation testing	0.25	0.25	0.25	0.25	0.25
				SANDSTROM, PERRY	Engineering support: IceCube Lab Summer operations, fieldwork management	0.25	0.25	0.25	0.25	0.25
	2.1.2 Engineering and R&D Support Total					**0.88**	**0.88**	**0.88**	**0.88**	**0.88**
	2.1.3 USAP and Safety Support	UW	Manager	HAUGEN, JAMES	USAP Support: yearly Support Information Package, coordination with contractor (ASC)	0.05	0.05	0.05	0.05	0.05
			Academic Staff	ZERNICK, MICHAEL	Safety manager	0.25	0.25	0.25	0.25	0.25
	2.1.3 USAP and Safety Support Total					**0.30**	**0.30**	**0.30**	**0.30**	**0.30**
	2.1.4 Education & Outreach	UW	Academic Staff	STEFFES, LINDSEY	Management of E&O events, collaboration meetings, website, and social networks	0.75	0.75	0.75	0.75	0.75
				CHILDRESS-BECHTOL, ELLEN	Evaluation support: framework design and implementation for Broader Impacts	0.50	0.50	0.50	0.50	0.50
				MADSEN, JAMES	Associate Director for Education & Outreach	0.50	0.50	0.50	0.50	0.50
				DEMERIT, JEAN	Editor / science writer, E&O support	0.25	0.25	0.25	0.25	0.25
				PAIRIN, JACK	Graphic Designer	0.25	0.25	0.25	0.25	0.25
	2.1.4 Education & Outreach Total					**2.25**	**2.25**	**2.25**	**2.25**	**2.25**
	2.1.5 Communications	UW	Academic Staff	O'KEEFE, MADELEINE	Communication plan manager, science writer. Masterclass and communication workshop coordinator	0.75	0.75	0.75	0.75	0.75
	2.1.5 Communications Total					**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
2.1 Program Coordination Total						**7.31**	**7.31**	**7.31**	**7.31**	**7.31**
2.2 Detector Ops. & Maint.	2.2.0 Detector Operations &	UW	Scientist	KELLEY, JOHN	Detector Maintenance and Operations Manager	0.50	0.50	0.50	0.50	0.50
	2.2.0 Detector Operations &					**0.50**	**0.50**	**0.50**	**0.50**	**0.50**
	2.2.1 Run Coordination	UW	System Administrator	AUER, RALF	Winterover coordinator, hiring and training of winterovers	0.20	0.20	0.20	0.20	0.20
			Winter Over	UW Winter Overs	Operate Detector (Winterovers)	1.50	1.50	1.50	1.50	1.50
	2.2.1 Run Coordination Total					**1.70**	**1.70**	**1.70**	**1.70**	**1.70**
	2.2.2 Data Acquisition	UW	Scientist	KELLEY, JOHN	DOM software: DOR device driver, DOMHub scripts, DOMCal	0.25	0.25	0.25	0.25	0.25
			Software Engineer	BENDFELT, TIMOTHY	IceCube DAQ: StringHub and domapp; Upgrade integration	0.75	0.50	0.25	0.25	0.25
				GLOWACKI, DAVID	IceCube DAQ: command-and-control server, testing infrastructure	0.50	0.50	0.50	0.50	0.50
					IceCube DAQ: trigger and event builder	0.50	0.50	0.50	0.50	0.50
		PSU	Scientist	ANDERSON, TYLER	Firmware development and support for DOMHub upgrade	0.00	0.00	0.25	0.50	0.25
			Postdoctoral Scientist	FIENBERG, AARON	DOM firmware development and support	0.25	0.25	0.25	0.25	0.25
		LBNL	Engineer	STEZELBERGER, THORSTEN	Maintain DAQ Hardware (Hubs, DOR, Clocks, GPS)	0.15	0.15	0.15	0.15	0.15
	2.2.2 Data Acquisition Total					**2.40**	**2.15**	**2.15**	**2.40**	**2.15**
	2.2.3 Online Filter (Pnf)	UMD	Scientist	BLAUFUSS, ERIK	Maintain online filters	0.20	0.20	0.20	0.20	0.20
			Software Engineer	SCHMIDT, TORSTEN	Maintain and develop PnF software, support operations to respond to and debug unexpected errors	0.50	0.50	0.50	0.50	0.50
	2.2.3 Online Filter (Pnf) Total					**0.70**	**0.70**	**0.70**	**0.70**	**0.70**
	2.2.4 Detector Monitoring	UW	Scientist	KAUER, MATTHEW	Training and coordinating monitoring shifters	0.30	0.30	0.30	0.30	0.30
			Software Engineer	BRAUN, JAMES	I3MS Iridium messaging system software	0.43	0.43	0.50	0.50	0.50
				BURRESON, COLIN	IceCube Live monitoring system: web interface, databases	0.90	0.90	0.90	0.90	0.90

WBS Level 2	WBS Level 3	Institution	Labor Category	Names	Task	Year1 (FTE)	Year2 (FTE)	Year3 (FTE)	Year4 (FTE)	Year5 (FTE)
					Supernova alert interface, DAQ monitoring, and visualization in IceCube Live	0.10	0.10	0.10	0.10	0.10
				FRERE, MICHAEL	IceCube Live lead developer	0.75	0.75	0.75	0.75	0.75
		UD	Scientist	TILAV, SERAP	IceTop data monitoring	0.30	0.30	0.30	0.30	0.30
	2.2.4 Detector Monitoring Total					2.78	2.78	2.85	2.85	2.85
	2.2.5 Experiment Control	UW	Software Engineer	BRAUN, JAMES	IceCube LiveControl experiment control software: alerts and component communi	0.50	0.50	0.50	0.50	0.50
				FRERE, MICHAEL	IceCube LiveControl experiment control software: operator interface	0.25	0.25	0.25	0.25	0.25
	2.2.5 Experiment Control Total					0.75	0.75	0.75	0.75	0.75
	2.2.6 Surface Detector Operations	UW	Scientist	KAUER, MATTHEW	Test and commission experimental apparatus for restoring IceTop detector efficiency	0.20	0.20	0.20	0.20	0.20
				TOSI, DELIA	Surface detector upgrade lead; coordinate hardware and software development	0.25	0.25	0.25	0.25	0.25
			Engineer	SANDSTROM, PERRY	Support surface detector electronics development	0.25	0.25	0.25	0.25	0.25
		UD	Scientist	TILAV, SERAP	Coordinate IceTop Operations	0.30	0.30	0.30	0.30	0.30
	2.2.6 Surface Detector Operations Total					1.00	1.00	1.00	1.00	1.00
	2.2.7 Supernova System	UW	Software Engineer	BENDFELT, TIMOTHY	IceCube DAQ: supernova interface, hitspooling	0.25	0.50	0.75	0.75	0.75
	2.2.7 Supernova System Total					0.25	0.50	0.75	0.75	0.75
	2.2.8 Real-time Alerts	UMD	Scientist	BLAUFUSS, ERIK	Online realtime alert system implementation, realtime operations lead	0.20	0.20	0.20	0.20	0.20
	2.2.8 Real-time Alerts Total					0.20	0.20	0.20	0.20	0.20
	2.2.9 SPS/SPTS	UW	System Administrator	AUER, RALF	Maintain South Pole computing H/W infrastructure and operating systems	0.23	0.23	0.23	0.23	0.23
					Maintain South Pole Test System computing H/W Infrastructure and operating systems	0.10	0.10	0.10	0.10	0.10
		MSU	Software Engineer	NG, CHRISTOPHER	Northern Test System integration and maintenance	0.50	0.50	0.50	0.50	0.50
	2.2.9 SPS/SPTS Total					0.83	0.83	0.83	0.83	0.83
2.2 Detector Ops. & Maint. Total						11.11	11.11	11.43	11.68	11.43
2.3 Computing & Data Management	2.3.0 Computing & Data	UW	Manager	RIEDEL, BENEDIKT	Computing Infrastructure Manager	0.90	0.90	0.90	0.90	0.90
	2.3.0 Computing & Data Management Total					0.90	0.90	0.90	0.90	0.90
	2.3.1 Data Storage & Transfer	UW	Software Engineer	MEADE, PATRICK	Operate Data transfer from S. Pole to UW Data Warehouse and archive services at S. Pole	0.50	0.50	0.50	0.50	0.50
			System Administrator	BARNET, STEVE	Maintain and Operate Data Storage Infrastructure	0.30	0.30	0.30	0.30	0.30
				BELLINGER, JAMES	Long term preservation and archive services, data curation	1.00	1.00	1.00	1.00	1.00
				BRIK, VLADIMIR	Maintain storage system needed for simulation production	0.20	0.20	0.20	0.20	0.20
	2.3.1 Data Storage & Transfer Total					2.00	2.00	2.00	2.00	2.00
	2.3.2 Core Data Center Infrastructure	UW	System Administrator	BARNET, STEVE	Operations and cybersecurity manager	0.70	0.70	0.70	0.70	0.70
				BRIK, VLADIMIR	Maintain Core Data Center Infrastructure Systems	0.10	0.10	0.10	0.10	0.10
				MAYER, DAVID	IceCube Web Development	0.50	0.50	0.50	0.50	0.50
				SHEPERD, ALEC	Maintain and operate Virtual Machines deployment infrastrucutre	0.50	0.50	0.50	0.50	0.50
					Maintain Core Data Center Infrastructure Systems	0.25	0.25	0.25	0.25	0.25
	2.3.2 Core Data Center Infrastructure Total					2.05	2.05	2.05	2.05	2.05
	2.3.3 Central Computing Resources	UW	System Administrator	BRIK, VLADIMIR	Maintain High Performance Computing services.	0.10	0.10	0.10	0.10	0.10
				SHEPERD, ALEC	Maintain Central Computing Infrastructure Systems	0.25	0.25	0.25	0.25	0.25
				COMERFORD, DENNIS	End-user support for common collaboration services	0.45	0.60	0.60	0.60	0.60
	2.3.3 Central Computing Resources Total					0.80	0.95	0.95	0.95	0.95
	2.3.4 Distributed Computing Resources	UW	Software Engineer	WORKFLOW PROGRAMMER	Expand distributed resource pool and adjust workflow for new resources	0.00	0.25	1.00	1.00	1.00
			System Administrator	BRIK, VLADIMIR	Maintain distributed high-throughput cluster	0.60	0.60	0.60	0.60	0.60
				SCHULTZ, DAVID	Core distributed software maintenance	0.50	0.50	0.50	0.50	0.50
					Maintain workflow management system	0.40	0.40	0.40	0.40	0.40
					Manage Production Software Team	0.10	0.10	0.10	0.10	0.10
				EVANS, ERIC	Core software maintenance	0.50	0.50	0.50	0.50	0.50
		MSU	Postdoctoral Scientist	MSU PO	Simulation production site manager at MSU			0.25	0.25	0.25
				HALLIDAY, ROBERT	Simulation production site manager at MSU	0.25	0.25			
	2.3.4 Distributed Computing Resources Total					2.35	2.60	3.35	3.35	3.35
2.3 Computing & Data Management Total						8.10	8.50	9.25	9.25	9.25
2.4 Data Processing & Simulation Services	2.4.0 Data Processing and Simulation Services	UW	Data Scientist	DIAZ-VELEZ, JUAN CARLOS	Coordination of Offline Processing and Simulation Production efforts with analysis working groups	0.25	0.25	0.25	0.25	0.25
	2.4.0 Data Processing and Simulation Services Total					0.25	0.25	0.25	0.25	0.25
	2.4.1 Offline Data Production	UW	System Administrator	EVANS, ERIC	Data validation tool development	0.10	0.10	0.10	0.10	0.10
			Data Scientist	SNIHUR, ROBERT	Experimental data processing and reduction. Interface with collaboration working groups to deliver analysis-ready data	1.00	1.00	1.00	1.00	1.00

WBS Level 2	WBS Level 3	Institution	Labor Category	Names	Task	Year1 (FTE)	Year2 (FTE)	Year3 (FTE)	Year4 (FTE)	Year5 (FTE)
	2.4.1 Offline Data Production Total					**1.10**	**1.10**	**1.10**	**1.10**	**1.10**
	2.4.2 Simulation Production	UW	System Administrator	EVANS, ERIC	Simulation production monitoring and validation	0.40	0.40	0.40	0.40	0.40
			Data Scientist	DIAZ-VELEZ, JUAN CARLOS	Manage Centralized Simulation Production. Maintain, test and update physics aspects of the atmospheric muon and neutrino simulation	0.40	0.40	0.40	0.40	0.40
		UD	Postdoctoral Scientist	SOLDIN, DENNIS	IceCube/IceTop simulation production	0.25	0.25	0.25	0.25	0.25
	2.4.2 Simulation Production Total					**1.05**	**1.05**	**1.05**	**1.05**	**1.05**
2.4 Data Processing and Simulation Services Total						**2.40**	**2.40**	**2.40**	**2.40**	**2.40**
2.5 Software	2.5.0 Software	UMD	Software Engineer	OLIVAS, ALEX	IceCube Software Coordinator	0.75	0.75	0.75	0.75	0.75
					Core software maintenance, including the framework and i/o project	0.15	0.15	0.15	0.15	0.15
	2.5.0 Software Total					**0.90**	**0.90**	**0.90**	**0.90**	**0.90**
	2.5.1 Core Software	UW	Software Engineer	OFFLINE SUPPORT PROGRAMMER	Core support including framework, data I/O, waveforms tools	0.25	0.75	0.75	0.75	0.75
		UMD	Scientist	BLAUFUSS, ERIK	Filter requests, bandwidth, TFT Board Member	0.35	0.35	0.35	0.35	0.35
	2.5.1 Core Software Total					**0.60**	**1.10**	**1.10**	**1.10**	**1.10**
	2.5.2 Simulation Software	UW	Scientist	CHIRKIN, DMITRY	Maintain photon propagation project	0.10	0.10	0.10	0.10	0.10
				HOSHINA, KOTOYO	Support for neutrino simulations and earth model projects	0.33	0.33	0.33	0.33	0.33
			Software Engineer	SIMULATION PROGRAMMER (UPGRADE SUPPORT)	PMT, digitization (i.e. DOM MB) simulation, trigger and waveform support	0.25	1.00	1.00	1.00	1.00
				GPU PROGRAMMER	GPGPU and concurrency support for all modules that can benefit from concurrent hardware	0.50	1.00	1.00	1.00	1.00
			Data Scientist	DIAZ-VELEZ, JUAN CARLOS	Simulation software programs coordinator	0.25	0.25	0.25	0.25	0.25
				MEAGHER, KEVIN	Triggered CORSIKA maintenance and development	0.75	0.75	0.75	0.75	0.75
	2.5.2 Simulation Software Total					**2.18**	**3.43**	**3.43**	**3.43**	**3.43**
	2.5.3 Reconstruction	UW	Software Engineer	RECONSTRUCTION SUPPORT PROGRAMMER	Reconstruction framework support including resource optimizations	0.00	1.00	1.00	1.00	1.00
			Data Scientist	MEAGHER, KEVIN	Reconstruction software programs coordinator	0.25	0.25	0.25	0.25	0.25
	2.5.3 Reconstruction Total					**0.25**	**1.25**	**1.25**	**1.25**	**1.25**
	2.5.4 Science Support Tools	UW	Software Engineer	VISUALIZATION PROGRAMMER	Maintenance of IceCube's visualization project	0.00	0.25	0.25	0.25	0.25
	2.5.4 Science Support Tools Total					**0.00**	**0.25**	**0.25**	**0.25**	**0.25**
	2.5.5 Software Development Infrastructure	UMD	Software Engineer	LADIEU, DON	Maintenance of DevOps systems, e.g. build, test coverage, CI/CD, VCS, and workflow policy	0.75	0.75	0.75	0.75	0.75
	2.5.5 Software Development Infrastructure Total					**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
2.5 Software Total						**4.68**	**7.68**	**7.68**	**7.68**	**7.68**
2.6 Calibration	2.6.0 Calibration	UA	Faculty	WILLIAMS, DAWN	Baseline and charge harvesting and DOMCal	0.08	0.08	0.08	0.08	0.08
	2.6.0 Calibration Total					**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
	2.6.2 Ice Properties	UW	Scientist	CHIRKIN, DMITRY	Direct photon tracking / ice properties calibration; reco S/W	0.65	0.65	0.65	0.65	0.65
				WENDT, CHRISTOPHER	Flasher output, flasher calibration	0.65	0.65	0.65	0.65	0.65
			Academic Staff	NUCKLES, JACK	Pencil beam, LED flasher support	1.00	1.00	1.00	1.00	1.00
	2.6.2 Ice Properties Total					**2.30**	**2.30**	**2.30**	**2.30**	**2.30**
2.6 Calibration Total						**2.38**	**2.38**	**2.38**	**2.38**	**2.38**
Grand Total						**35.98**	**39.38**	**40.45**	**40.70**	**40.45**