Distributed editing of experiment programs at Wendelstein 7-X





MAX-PLANCK-INSTITUT FUR PLASMAPHYSIK

Anett Spring¹, Heike Riemann, Marc Lewerentz, and the W7-X team Max-Planck-Institut für Plasmaphysik, Greifswald, Germany ¹ anett.spring@ipp.mpg.de

BACKGROUND - MOTIVATION

Wendelstein 7-X - as the world's largest stellarator-type fusion device - is equipped with an outstanding number of technical systems and diagnostic facilities compared to other fusion experiments.

Today, W7-X comprises more than

W7-X SEGMENT CONTROL

W7-X has been going successfully through its first operation phases showing reliable operation assisted by the W7-X Segment Control and experiment-planning framework. Integrated components and diagnostics at W7-X benefit from

- pre-checking for reasonability of program parameter settings
- complete program description of all component parameters in a "planned program"
- central event-based segment switching
- continuous data streaming and monitoring, standardized parameter logging

40 systems integrated into the Segment Control framework with far more than 200 ControlStations.

... and the use of common CoDaC applications for experiment preparation, execution, monitoring, and data access

EXPERIMENT PLANNING AT W7-X

CHALLENGE: COMPLEXITY

SOLUTION

- demand of complete overview of the involved components
- need for validating potential constraints and dependencies \bullet
- amount of parameters and required expert knowledge lacksquare
- compliance of component tasks with the experiment program timing

Distributed editing by

- overlay component parameters into the planned sequence of the ● central experiment program using a common reference for the segment structure
- linking component Tasks (as aggregation of parameters) to ulletranges in experiment programs

IMPLEMENTATION OF TASK LINKS

TaskLink = Task + range in a Planned Program (PP) sequence to be **linked** in

TaskLinks Manager

MasterPP

ExpProgram Editor

- refers to a MasterProgram
- persistent in programs database

CHALLENGE: TEAM WORK

- focus on the users requirements both the experiment leaders and component owners
- define workflow for joint editing: announce / visualize / apply parameter changes
- sufficiently flexible framework to handle different timing structures in planned experiment programs



edit tasks in (a blueprint of) the MasterPP	persist ranges + tasks in TaskLinks Table(s)	review differences and adopt tasks as linked to MasterPP	persist as complete PP
--	---	--	------------------------

INTEGRATION IN W7-X PROGRAM EDITOR XEDIT

Edit Task Links for CHE Steady State Pellet Inj	ector MasterPP:488893					×
📱 Submit TaskLinks 🛛 🐺 Submit and exit	🖅 Refresh others 🛛 🕐					
MasterPP:488893 SegmentControl						
st ECRH 500 kW ECRH energy 0	.01 MJ ECRH pol X2-mode ECRH di	uration 0.03 s B5 Gas3 He [BG031, BG033] FeedForwa	ard Pellet Gas H	H21 N2 FeedForwa	rd TC CC
t6						
t6						
t6 .ntContro∏est 10s					hkl [2024-05-08 06	:45 UTC; 404287
					hkl [2024-05-08 06	:45 UTC; 404287
					hki (2024-05-08 06	:45 UTC; 404287
	56.0			19.51	hkl [2024-05-08 06	:45 UTC; 40428; 10.0
	56.0	10.5	6.0 3.0 1.5		hkl [2024-05-08 06	
.ntControiTest 10s		10.5	6.0 3.0 1.5	19.51		10.0
.ntControiTest 10s		10.5	6.0 3.0 1.5	19.51		10.0
.ntControiTest 10s		10.5	6.0 3.0 1.5	19.51		10.0



USER EXPERIENCE

Successful deployment at W7-X in the recent operating phase with great user acceptance.

Users work in their well-known environment for parameter editing, equivalent to stand-alone operation and even have other components' settings as reference. The adoption of the TaskLinks by the experiment leaders is visually for the apparent component owners at program's runtime.

Machine [ACM, AA Operational Diagnostics [QMJ, QX Invasive Diagnostics [QHF, QOI	24 26 28 ration [1.2] 9.5 20, CDX21, DO 20, CDX21, DO 20, QME, QTB, Q QRN, QSH, QS	[1.3] [1.4] 10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]	[2] plasma [2.1] [2.2]	[2.3] 1.5 [2.:	Injection Plasma 60 62 64 68 70 [2.4] [2.5] 10.0 0.01 2.2 2.5] Manage Task Links E Steady State Pellet Inje	Inactive IS_ENTRY End 72 74 76 78 80 82 84 (3) PostP (2.6) (3.1) 4.0 10.0 [2.6 3.1]	
Start Preparation 0 2 4 6 8 10 12 14 16 18 20 22 4 ••••••••••••••••••••••••••••••••••••	ration [1.2] 9.5 20, CDX21, DO 2] , QME, QTB, Q QRN, QSH, QS	[1.3] [1.4] 10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]	Continue 42 44 46 48 50 52 54 11 [2] plasma [2.1] [2.2]	[2.3] 1.5 [2.:	60 62 64 66 68 70 1 [2.4] [2.5] 10.0 0.01 2.2 2.5] Manage Task Links	End 72 74 76 78 80 82 84 [3] PostP [2.6] [3.1] 4.0 10.0	
Image: Segment duration [s] [1] preprint [1.1] Segment duration [s] 30.0 CHE Steady State Pellet Injector [] Central [DBB] Heating & Fueling [CBG, CD2 Machine [ACM, AA Operational Diagnostics [QMJ, QX Invasive Diagnostics [QHF, QOI	ration [1.2] 9.5 20, CDX21, DO 2] , QME, QTB, Q QRN, QSH, QS	[1.3] [1.4] 10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]	[2] plasma [2.1] [2.2]	[2.3] 1.5 [2.:	[2.4] [2.5] 10.0 0.01 2.2 2.5] Manage Task Links	[3] PostP [2.6] [3.1] 4.0 10.0	
(1) prep. [1] prep. [1] [1,1] Segment duration [s] 30.0 CHE Steady State Pellet Injector Central [DBB] Heating & Fueling [CBG, CD) Machine [ACM, AA Operational Diagnostics [QHF, QOI	[1.2] 9.5 20, CDX21, DO 2] , QME, QTB, Q QRN, QSH, QS	10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]] [2.1] [2.2]	1.5 [2.:	10.0 0.01 2.2 2.5] Manage Task Links	[2.6] [3.1] 4.0 10.0	
[1.1] Segment duration [s] 30.0 CHE Steady State Pellet Injector Central [DBB] Heating & Fueling [CBG, CD) Machine [ACM, AA Operational Diagnostics [QMJ, QX) Invasive Diagnostics [QHF, QOI	[1.2] 9.5 20, CDX21, DO 2] , QME, QTB, Q QRN, QSH, QS	10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]] [2.1] [2.2]	1.5 [2.:	10.0 0.01 2.2 2.5] Manage Task Links	[2.6] [3.1] 4.0 10.0	
[1.1] Segment duration [s] 30.0 CHE Steady State Pellet Injector Central [DBB] Heating & Fueling [CBG, CD) Machine [ACM, AA Operational Diagnostics [QMJ, QX) Invasive Diagnostics [QHF, QOI	[1.2] 9.5 20, CDX21, DO 2] , QME, QTB, Q QRN, QSH, QS	10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]] [2.1] [2.2]	1.5 [2.:	10.0 0.01 2.2 2.5] Manage Task Links	[2.6] [3.1] 4.0 10.0	
Segment duration [s] 30.0 CHE Steady State Pellet Injector 1 Central [DBB] Heating & Fueling [CBG, CD] Machine [ACM, AA Operational Diagnostics [QMJ, QX Invasive Diagnostics [QHF, QOI	9.5 20, CDX21, DO 21, QME, QTB, Q QRN, QSH, QS	10.5 6.0 [1.1 2.1] CH] QRG, QRT02, QSD, QMR]		1.5 [2.:	10.0 0.01 2.2 2.5] Manage Task Links	4.0 10.0	
CHE Steady State Pellet InjectorDCentral[DBB]Heating & Fueling[CBG, CD2Machine[ACM, AAOperational Diagnostics[QMJ, QXInvasive Diagnostics[QHF, QOI	20, CDX21, DO \] , QME, QTB, (QRN, QSH, QS	[1.1 2.1] CH] QRG, QRT02, QSD, QMR]		[2.:	2.2 2.5] Manage Task Links		
Central[DBB]Heating & Fueling[CBG, CD]Machine[ACM, AAOperational Diagnostics[QMJ, QX]Invasive Diagnostics[QHF, QO]	N] , QME, QTB, Q QRN, QSH, QS	CH] QRG, QRT02, QSD, QMR]			Manage Task Links	[2:0 0.1]	
Heating & Fueling[CBG, CD]Machine[ACM, AAOperational Diagnostics[QMJ, QXInvasive Diagnostics[QHF, QOI	N] , QME, QTB, Q QRN, QSH, QS	QRG, QRT02, QSD, QMR]			-		
Machine[ACM, AAOperational Diagnostics[QMJ, QXInvasive Diagnostics[QHF, QOI	N] , QME, QTB, Q QRN, QSH, QS	QRG, QRT02, QSD, QMR]			-		
Operational Diagnostics [QMJ, QX Invasive Diagnostics [QHF, QOI	, QME, QTB, Q QRN, QSH, QS			CHES	E Stoody State Ballet Inio		
Invasive Diagnostics [QHF, QOI	QRN, QSH, QS				steady state Pellet Inje	ctor [1]	
	J, GIVIC, GIVIF		QRI, QRP02, QRR, QSC, QSK, Q	SR0:	New 🔡 Duplicate	📓 Delete 🛛 🕸 View / Edit 🛛 🔞	
					IA		
					efault		
∓ 🖫 🗔	unit	[1.1 2.1]	[2.2 2.5]		Global or other rela	ted MasterPRs:	🖌 default 🔤 d
E Steady State Pellet Injector						ited masterres.	
Operation Mode		Active	Active	488	38893		
	s	Preparation 40	Pellet Injection				
 Delay to open gate valve Pellet size 	mm	40					
Injection start	ms	I	2100	Ran	nges and TaskLinks: (9	🖽 Add 📑 Rem
Injection duration	ms		8000				
Pellet period	ms		500		start [scen.seg]	end [scen.seg]	TaskID
Duration of chambering mechan	sm µs		16E3	1.1		2.1	430
Propellant valve delay	μs		13E3	2.2		22	555
Propellant valve duration	μs		1100	21	1	31	39(

	Segment duration [s]		[1.1] 30.0	[1.2] 9.5	[1.3] 10.5	[1.4] 6.0	[2.1] 3.0	[2.2] 1.0	[2.3] 1.5	[2.4] 2.6	[2.5] 0.01	[2.6] 4.0	[3.1] 5.0
	Central												
	DBB CentralControl	Þ	[1.1]	[1.2]	[1.3]	[1.4]	[2.1]	[2.2]	[2.3]	[2.4]	[2.5]	[2.6]	[3.1]
	Heating & Fueling												
	CBG ECRH	Þ		[1.1	1.4]				[2.1 2.5]			[2.6.	3.1]
	CDX20 NBI							[1.1 3.1]					
	CDX21 NBI							[1.1 3.1]					
	DCH GasInlet		[1.1]			[1.2 2.2]			[2.3	2.4]		[2.5 3.1]	
	GHE Steady State Pellet Injector	Þ						[1.1 3.1]				_	
1	Machine												
	ACM ControlCoils							[1.1 3.1]					
	AAQ TrimCoils	Þ		[1.1 1.3]					[1.4 2.6]				[3.1]
	Operational Diagnostics												
	a QMJ Interferometry	D	[1.1]	[1.2]	[1.3]	[1.4]			[2.1.	2.6]			[3.1]
	QXG Magnetics	D			[1.1 2.1]					[2.2 2.6]			[3.1]
	G QME ECE	Þ		[1.1]	1.4]				[2.1.	2.6]			[3.1]
	👦 QTB ThomsonScattering	Þ				-	[1.1	2.6]					[3.1]
	RG NeutralGas	Þ					[1.1	2.6]					[3.1]
	RT02 DivertorProtection	Þ	[1.1]	[1.2]	[1.3	1.4]				[2.1 3.1]			
	QSD HEXOS				[1.1 2.1]					[2.2 2.6]			[3.1]
	OMR Dopplerreflectometer	D		[1.1	1 41		[21]	2 21		[2:3	2 61		[3 1]
E	<u>∓</u> 🖫 😱			unit			[2.1 2.6]				set com	non value	
	ME ECE												
9	Component Status						Active Plasma				Plas		
	Acquisition Mode					4	Acquisition				Pida	sina	
	Offset Determination												
	Y T X2 Radiometer						Active						
	Sample Frequency			Hz			1E6				11	E6	
	- 🕼 X3 Radiometer •- 🕼 Zoom System						Inactive Active						
	Sample Frequency			Hz			1E6				11	E6	

The experiment leaders are still in charge to decide whether to adopt TaskLinks.

Poster No.102 - IAEA Technical Meeting on Control Systems, Data Acquisition Data Management and Remote Participation in Fusion Research. São Paulo 2024

Apply

OK

Help

Cancel



his work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission ither the European Union nor the European Commission can be held responsible for them

