Action Plan towards Demo

Examples

Black: Kick off of Items
Red : Close of items

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ … 2035~
#. Field of R&D	Action 1 (2015 → 2025~); Action 2 (2015 → 2020~)		
Issue 1	(kick off) Action name --------------------------- (15)Action 1 --------------------------------------	---> (close) --> (25)	######################### →(*) **(*) :The issue will be developed after 2035**
Issue 2	**If the issue is closed during the same time window:** (kick off) Action name -> (close) (15) Action 2 →(19)		

<u>Organization expected to be in charge</u>

G : Japanese Government
S : Joint Special Design Team for DEMO
Q : QST (Dep. of Fusion)
N : NIFS
U : Universities
D : Industries
F : Fusion Energy Forum

C1～C5 : See the list (right)
A : Academies
I : ITER team in JP
M: National Institute of material Science
Qw: QST(West)
TF: Task Force
HQ: Head Quarter for Outreach

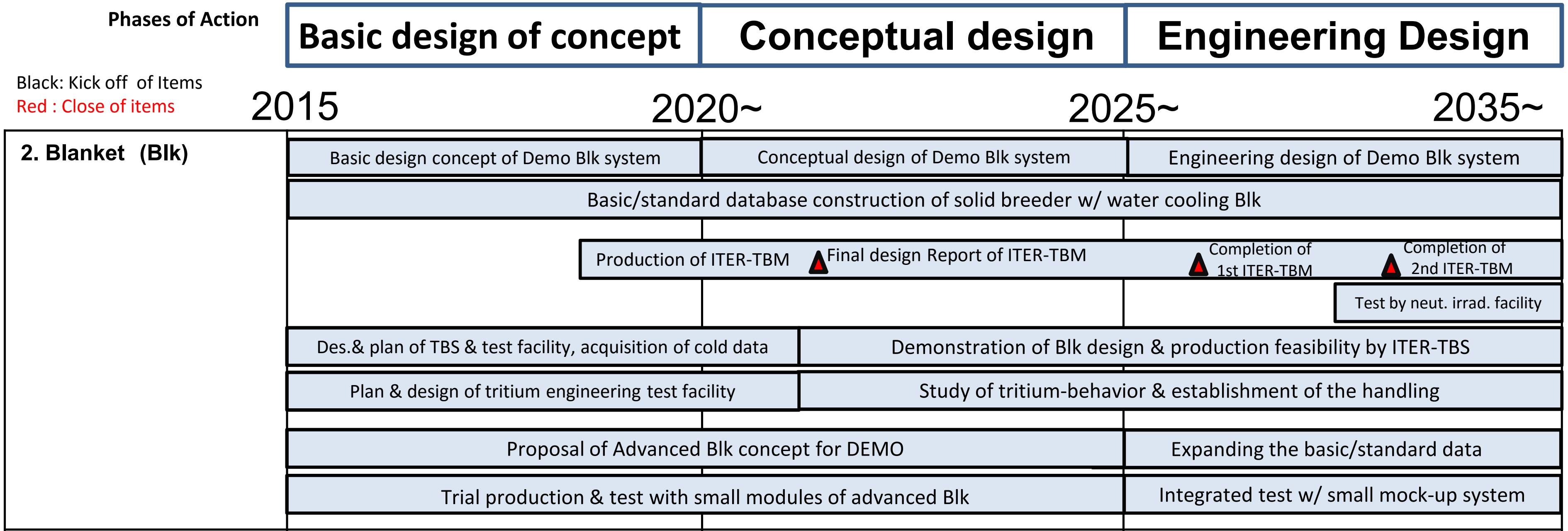
List of Center and Labs

C1 : Ins. of Laser Engineering Osaka University
C2 : Institute of Advanced Energy Kyoto University
C3 : Plasma Research Center. University of Tsukuba
C4 : Res. Ins. for Applied Mechanics Kyushu University
C5 : Hydrogen Isotope Research Center Univ. Toyama

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ … 2035~

	2015–	2020~	2025~
0.Demo Design	Conceptual design	Conceptual design	Engineering design
	Establishment of phys.& eng. guideline		Site asses. / Const. design Decision of site ▲
	Definition of safety policy	Preparation for regulation of safety	Regulation and assessment for site safety
	Database(DB) of physics, engineering & materials	Database(DB) of physics, engineering & materials	DB update w/JT-60SA & irradiation results
Concept & Construction plan	(15)S: Phys.& eng. guideline →(19) (15)S: Basic design of concept →(19) (16)S/TF: Fuel cycle strategy ------------------ (17)Q/N/U/S: Integrated simulator --------- (18)S/D: Cost evaluation -----------------------	(20)S/D: Conceptual design →(26) --> (26) --> (26) (23)S/Q/F: Rev. of target plasma →(26) -->	(27)D/S: Design of Demo core parts →(35) --> (31) (29)G/TF: Decision of candidate site →(31) (32)G: Site assessment →(35)
Equipment Design	(15)S/Q: Basic design of SC →(19) (19)S/Q: Demo TBM targets →(19) (17)S/D: Equip. config. w/BOP →(19)	(21)S/D: Conceptual Design of BOP →(26)	**(for site asses.)** (27)D/S: Design of plant, build..& Equip. →(31) (27)A/S: Regulation & standard →(31) **(after decision of standard & site candidates)** (32)D/S: Design plant/build./equip →(35)
Safety Policy	(16)S/D: Draft of safety policy →(19)	(20) S/D: Asses. of Safety aspect --------------- (20)S/D: Asses. of Safety aspect →(26) (20)TF/S: Draft for safety regulation →(26)	--> (31) (27)G/TF: Safety regulation →(35) (32)G: Safety assessment →(35)
Database of Physics, Engineering & Materials	(16)Q/U/F/S: Demo Phys. DB ------------------ (16)Q/U/F/S: Eng. & Materials DB -------------	-->(26) -->(26)	(27)Q/S: Update Eng.& materials DB →(31) **w/ results by JT-60SA** (32)Q/S: Update material DB →(35) **w/ 14MeV heavy irradiation data**

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ 2035~
1.Super-conducting Coils (SC)	Basic design of SC concept Study of SC test facility Related BOP (cooling, coil power supply) Basic design of concept	SC conceptual design SC element trial production & test Related BOP (cooling, coil power supply) Conceptual design	SC engineering design Test of Coils Related BOP (cooling, coil power supply) Engineering design
SC Design	(15) S/Q/D: Basic design of concept →(19) (15)S/Q/N/M/U: Decision of major option for SC conductor →(19) (18)S/Q/U/D: Proposal of R&D plan →(19)	(20)S/Q/D: SC conceptual design → (26) (20)S/Q/N: Conceptual design of SC conductor→(26)	(27) Q/D/S: SC engineering design →(35) (27) Q/D/S: Study of SC production & construction →(35)
SC conductor & Coil tests	(17)Q/N/S: Study of test facility for SC conductor→(19)	(20)Q/N/S: Test facility for SC conductor→(26) (20)Q/N/D: Test of SC conductor --------------------	(27)Q/N/S: Coil test facility → (35) (27)Q/D/N: Coil test → (35) ---> (33)
High Strength Structural Materials & Radiation-proof Materials	(15)Q/M/S: Study of high strength materials →(19) (15)Q/S: Study of radiation-proof materials→(19)	(20)Q/D/S: Trial production & test of high strength materials ----- (20) Q/D/S: Trial production & test of Radiation-proof materials -----	---> (33) ---> (33)
Related BOP (cooling, coil power supply)	(15)S/Q: Basic design concepts of cooling & coil power supply→(19)	(20)Q/S: Conceptual design of cooling & coil power supply → (26)	(27)Q/D/S: Engineering design of cooling & coil power supply → (35)



	2015	2020~	2025~
Solid Breeder w/ Water-cooling Blanket	(15) Q/S: Establishment of Basic/standard database --------	-->	--> (35)
	(15)S/Q/D: Basic design concept of Demo Blk system→(19)	(20)S/Q/D: Conceptual design of Demo Blk system→(26)	(27)S/Q/D: Engineering design of Demo Blk system→(35)
	(18)Q: Production of ITER-TBM ---------------	-->	---(35)
	(15)Q: Design & plan of TBS & test facility and acquisition of data w/ cold test ----	--------> (21)	(30)Q/U: Fus. neutron irradiation test →(35)
	(15)Q: Plan & design of tritium engineering test facility----	--------> (21)	
		(22)Q: Demonstration of Blk design & production feasibility by ITER-TBS ----	--> (35)
		(22)Q: Study of tritium-behavior & establishment of the handling ----	--> (35)
Advanced Blanket	(15)S/N/U: Proposal of Advanced Blk concept for DEMO ----	--> (26)	(26)N/U/S: Expanding the basic/standard data →(31)
	(15)N/U: Trial production & test with small modules of advanced Blk ----	--> (26)	(27)S/N/U: Integrated test with small mock-up system →(35)
	(15) N/U: Integrated flow loop test under real environment ----	-->	--> (31)

Phases of Action: **Basic design of concept** | **Conceptual design** | **Engineering Design**

Black: Kick off of Items
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2015 — 2020~ — 2025~ — 2035~

3. Divertor (Div)

- Development & validation of Divertor simulation code (2015–2035~)
- Development & validation of control method based on plasma experiments (2015–2035~)
- Conceptual design & operation scenario of divertor (2020~–2025~)
- Engineering design of divertor (2025~–2035~)
- Validation of Div equipments (2015–2020~)
- Decision on applicability of divertor equipments (2020~–2025~)
- Assessment of advanced divertor (2015–2020~)
- ▲ Decision of divertor concept for Demo (2025~)
- Validation and development of effects, maintenance & repair technologies (2015–2035~)

	Basic design of concept (2015–2020~)	Conceptual design (2020~–2025~)	Engineering Design (2025~–2035~)
Div Development Targets The Feasibility & Applicability for Demo-design	(18)S/Q/N/U: Decision on applicability of W + water cooling divertor for Demo ---- (15)S/Q/N/U: Assessment of advanced divertor & decision making for the development →(19) (16)Q/N/U/S: Heat-load test facility for plasma facing comp., Development & cold test ----	--> (26) --> (26)	(27)S/D: Engineering Design of Div system →(35) (27) Q/N/U/S: Heat-load test data of plasma facing components →(35)
Plasma Operation Scenario	(16)Q/S/U: Development of Div plasma simulation--- (16)Q/N/U/C3: Steady state & Div-like high density plasma test facility; Devel. & exp. ---- (16)Q/N/U: Development of real time control scheme for detached plasma -----	--> (26) (24)Q/N/U: Proposal of plasma scenario by integrated code ---- --> (26) --> (26) (20)Q/N/U: Test of real time control scheme for detached plasma by ITER/JT-60SA ---- (20)Q/N/U: Optimization of Div system by JT-60SA ----	(27)Q/N/U: Reproduction of ITER/JT-60SA plasma by Div plasma simulation→(35) --> (35) --> (35) --> (35)
Development of Material & Devices	(15)Q/N/U: Neutron radiation effects of Div component materials--- (16)S/Q/U/D: Validation and development of effects, maintenance & repair technologies ---	--> --> (26)	--> (35)
Particle Flow Control	(16)Q/N/U/S: Simulation code of particle behavior in vessel --- (16)S/Q/N/D: Study of exhaust system for Demo ---	--> (23)S/Q/N/U: Simulation of Tritium behavior in realistic conditions ---- --> (26)	--> (35) --> (35)

Phases of Action: Basic design of concept (2015–2020~) | Conceptual design (2020~–2025~) | Engineering Design (2025~–2035~)

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	2015	2020~	2025~ 2035~
4. Heating and Current Drive Systems (NBTF: NBI Test Facility)	Development of Fundamental Technologies by ITER/JT-60SA; NBTF power supply	NBTF power supply; JT-60SA ECH; NBTF beam & JT-60SA NB; Achievement of technological reliability under radioactive conditions through the ITER construction and operation; ITER ECH; Dev. of fundamental technology for Demo	NBTF; Achievement of ITER beam target & Contribution to JT-60SA NBI plasma experiments; ITER NBI; Establishment of technologies for Demo
Decision of Technol. Specification	(17)S/Q: Decision of ECH/NBI Technological specification ---	--->(26)	
Construction of Test Facility for Demo		(20)Q/N: Test facility of maintenance free negative ion source →(26)	(27)Q/N: ECH test facility for Demo →(35)
Realization of High Power & Steady State	(17)Q: Achievement of high power & long pulse in ITER ECH system ---- (17)Q: Achievement of high power & long pulse in ITER NBI system ----	---> (26) (20)Q/N/U: Tech. development of high power & steady state ECH system for Demo ---- ---> (26) (22)Q/N: Conceptual design of steady state & long pulse NBI for Demo→ (26)	---> (35) (27)Q/N: Technol. Development of Steady state & high power NBI for Demo → (35)
Achievement of Reliability	(15)Q/N: Conceptual design of reliable ECH (mirrorless/variable freq. /easy maintenance) -- (17)Q/N/U: Conceptual design of reliable NBI (maintenance-free IS, remote maintenance) ----	---> (26) (20)Q/N: Development of radiation-proof material for ECH & NB ---- ---> (26)	(27) Q/N: Establishment of reliable Technologies of ECH for Demo → (35) ---> (35) (27)Q/N/U: Dev. & test of reliable Launcher for ECH → (35) (27)Q/N/U: Establishment of basic technologies for reliable NBI → (35)
Achievement of High efficiency		(20)Q/N/D: Advancement of ECH energy recovery technology --- (20)Q/N/U: Dev. of high quality elec. beam ------ (29)Q/N/U: Conceptual design of high efficient NBI → (26)	---> (35) ---> (35) (27)Q/N/U: Development of NBI technology for high efficiency→ (35)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ 2035~

5. Theory & Simulation (SMC: simulation code)	2015–	2020~	2025~
	Development & use of SMCs for core plasma with 1st principle type		
	Focused development & use of Div. SMC	Application of Div. SMC to JT-60SA & ITER, validation & successive development	
	Dev. & use of integrated core plasma SMC	Application of core plasma SMC to JT-60SA & ITER, validation & successive development	
	Development & use of element-codes for material SMC		Dev. & use integ. material SMC, expanding of application, combi. w/ integ. Demo system code
		Development, use & validation of integrated code for materials	
	Dev. & use of SMCs for basic engineering	Dev. & use basic Demo system code	Dev. & use integrated Demo system code
	Modeling for plasma response and control	Development & use of operation simulator available for prediction of plant behavior	

SMCs for core plasma with 1st principle	(15)Q/N/U: Focused dev. & use of 1st Principle type SMC for plasma edge → (19)	(20)Q/N/U/S: Focused dev. & use of 1st principle type SMS for disruption, burning plasma, transport with turbulent flow(*) ----	--> (*)
Divertor (Div) SMC	(15)Q/N/U/S: Focused development & use of Div SMC→ (19)	(20)Q/N/U/S: Application of Div SMC to JT-60SA & ITER, validation & successive development ---	--> (35)
Integrated SMC for Core Plasma	(15)Q/N/U/S: Dev. & use of integrated core plasma SMC→ (19)	(20)Q/N/U/S: Application of core plasma SMC to JT-60SA & ITER, validation & successive dev. -----	--> (*) (27)Q/N/U/S: Improv. & appl. of core plasma integrated SMC toward Demo →(*)
SMC for Fusion Materials	(15)Q/N/U/S: Development & use of element-codes for material SMC ----	--> (26) (19)Q/N/U/S: Development, use & validation of integrated code for materials ----	--> (35) --> (35)
Integrated SMS for Demo System Design	(15)Q/N/U/S: Development & use of SMCs for basic engineering→ (20)	(20)Q/N/U/S: Development & use basic Demo system codes→ (26)	(27)Q/N/U/S: Development & use integrated Demo system codes→ (35)
Simulator for Operation Control of Demo	(15)Q/N/U/S: Modeling for plasma response and control → (19)	(20)Q/N/U/S: Development & use of operation simulator available for prediction of plant behavior -----	--> (35)

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Red : Close of items

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ 2035~
6. Core Plasma	LHD: Deuterium experiment JT-60SA: Initial research phase	JT-60SA: Initial research phase / Integrated research phase LHD: Deuterium experiment	ITER: H/He operation / DT Operation JT-60SA: Integrated research phase / Extended research phase
Plasma Design	(15)S: Physics design & decision of plasma parameters → (19) (15)S: Establ. of plasma design DB → (19)	(20)S: Optimization of plasma parameters -------- (20)S: Revision of plasma design DB ----------------	--> (*) --> (*)
ITER	(15)Q/N/U: Revision of ITER research plan ------	--> (24) (25)I: First plasma of ITER → (25)	(29)I: Establ. of plasma cont. method → (30) (29)I: Clarification of heated plasma physics (incl. disruption & ELM control) → (34) (35)I: Achievement of Q=10 → (*)
JT-60SA	(15)Q/N/U: Revision of JT-60SA research plan → (19) (20)Q/N/U: First plasma → (20) (20)Q/N/U: Establish. of plasma control method(21)	--->(21) (23)Q/N/U: Invest. of heated plasma physics (incl. disruption & ELM cont.) →(24) (24)Q/N/U: Demo. of high beta SS op. → (27) (24)Q/N/U: High confinement plasma with high density → (28) (24)Q/N/U: Demonstration of particle control (D, He, impurities) →(27) (25)Q/N/U: 100sec SS operation w/ high beta→ (28) (25)Q/N/U: Simultaneous achievement of plasma parameters toward Demo→ (28)	(30)Q/N/U: : Invest. of heated plasma physics with W-Div →(32) (30)Q/N/U: Demo. of high beta SS operation with W-Div →(32) (30)Q/N/U: : High density & high confinement plasma with W-Div →(32) (30)Q/N/U: Demonstration of particle control with W-Div (D, He, impurities) →(32) (32)Q/N/U: 100sec high beta SS operation with W-Div →(35) (32)Q/N/U: : Simultaneous achiev. of plasma parameters toward Demo with W-Div →(35)
LHD, Heliotron-J	(15)N/C2: Understanding about physics of torus system --- (16)N: Deuterium experiment --------------------- (16)N: Demonstration of particle control (D, He, impurities) →(19)	--> (25) --> (25)	
Study of Plasma/wall Interaction	(15)U:/C3/C4: PW basic data for W-material (17)U/C3/C4: Clarification of issues on W-div under long pulse operation ----	--> (26) --> (26)	
Modeling & Simulation	(16)Q/N/U: Establishment of physical model & expansion of plasma prediction code →(19)	(20)Q/N/U: Development of plasma control simulator (incl. application to ITER, JT-60SA, etc.)	--> (*)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ 2035~
7. Fuel System	Development of elemental Technology		Demonstration by ITER (incl. TBM)
		Design study of facility for handling of huge T	Const. & demo of facility for handling of huge T
	Establishment of Li securement technology in pilot plant scale		Li securement technology in plant scale
Design Study of Fuel Recycling System	(15)S/Q/U: Decision of fuel cycle scenario →(18) (15)S/Q/U: Evaluation of Fuel inventory →(18) (18)S/Q/U: Decision of fuel recycling system design →(19)	(20)Q/N/C5/U: Demonstration of fuel cycle scenario →(26) (25)Q/N/C5/U: Verification of fuel recycling system design →(26)	
Development of Fuel Recycling System	(15)Q/C5/U: Development of Elemental technology for fuel recycling system (impurity control, isotope separation, etc.) ----	--> (26)	(25)I: Demonstration of integrated fuel recycling system for plant →(*) (28)Q/C5/U: Development of fuel recycling system (incl. comparison w/ ITER) →(35) (30)Q: Demonstration of fuel recycling system with huge amount of Tritium →(35)
Development of Safe Handling & Equipments for Tritium	(15)Q/C5/U: Verification of tritium removal & control ---- (15)Q/C5/U: Basic data for Tritium material interaction →(19)	--> (24) (20)Q/C5: Elemental test of equipments in fuel cycle for gas & water with tritium →(26)	(27)I: Hoard of safe handling of tritium for plant →(*) (30)Q: Hoard of safe handling in facility for huge tritium →(35) (27)Q/C5: Feasibility test of equipments in fuel cycle for gas & water with tritium →(35) (35)Q: Integrated test of equipments for gas & water with tritium (incl. BOP) →(*)
Facility for handling of huge amount of Tritium		(20)Q: Design study of facility for handling of huge amount of tritium →(26)	(27)Q: Construction of facility for handling of huge amount of tritium →(30)
Securement of Lithium	(15)Q: Planning for securement of ^{6}Li →(17) (18)Q/D: Establishment of a way for Li securement in pilot plant scale --- (18)Q: Devel. of ^{6}Li separation basic technol. ---	--> (26) --> (26)	(27)Q: Establishment of a way for Li securement in full plant scale →(35) (27)Q: Establishment. of ^{6}Li separation →(35)
Initial load Tritium	(15)S/U: Assessment of T production →(19)	(20)S/Q/U: Study of securement way for initial load Tritium →(23) (24)Q: Preparation of initial load Tritium ---------	--> (35) (25)Q: Preparation for start-up scenario w/o initial load Tritium →(35)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ … 2035~

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Red : Close of items

8.Fusion Materials & Standard, Code (1)Structure Materials for Blanket (Blk)

FNS:Fusion Neutron Source

- Clarification of material spec. for Demo / Proposal of technical spec. for structure material (2015–2025)
- Mass-production technology / Blk structure production technology (2015–2025)
- Reliability evaluation & code of small specimen testing technology (2015–2025)
- Environment data of jointed cover parts (2015–2021)
- Irradiation data by fission reactors (2015–2028)
- Irradiation test by A-FNS (2029–2035)
- Evaluation of fusion neutron irradiation effects/irradiation-induced degradation model/Establishment of standards for structure design (2015–2035)
- Decision for utilization of advanced Blk materials (2015–2025)
- Expansion of database for advanced Blk materials (2015–2035)

	2015–2020	2020–2025	2025–2035
Low activation Ferritic Steel	(15)Q/S/U: Clarification of material spec. & technical spec. for Demo ---	----------------------------> (26)	
	(15)Q/D: Mass-production ----------------------------	----------------------------> (26)	
	(15)Q/D: Establishment of Blk structure production technology ----	----------------------------> (26)	
	(15)Q/D/A: Reliability evaluation & code of small specimen testing technology ----	----------------------------> (26)	
	(15)Q: Environment data of jointed cover parts by cold test ---	----------> (22)	
	(15)Q: 80dpa data by fission reactor →(19)	(20)Q: Verification of 80dpa data by fission reactor →(26)	
	(15)Q: Environment data of jointed cover parts ----	---------------------------->	----------------------------> (31) (30)Q: Irradiation test by A-FNS →(35)
	(15)Q/N/U: Evaluation of effects of He & fusion neutron irradiation, establishment of degradation model ----	---------------------------->	----------------------------> (35) (27)Q/D/A: Structural design code based on the irradiation results→(35)
	(15)Q/D/A: Policy towards structural design code based on irradiation results----	----------------------------> (26)	
	(15)Q/D/A: Academic activity towards material codes ----	---------------------------->	----------------------------> (35)
Advanced Blk Materials	(15)S/Q/N/U: Decision for utilization of advanced Blk materials ----	----------------------------> (26)	
	(15)Q/N/U: Expansion of database for advanced Blk materials ----	---------------------------->	----------------------------> (35)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design

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	2015	2020~	2025~	2035~
8.Fusion Materials & Standard, Code (2)Other materials	Optimization of production and recycling of functional breeding materials	Evaluation of irradiation effect by fission reactor		Test by A-FNS
		Evaluation of mech. data & establishment of production for breeders (ITER-TBM #2)		
		Securement technology for Lithium (Li)		
(3)Fusion Neutron Source (FNS)	Devel. of irradiation resistant Div materials, evaluation of irradiation effects by fission reactor			Test by A-FNS
	Irradiation effect database for diagnostics / control materials, by fission reactor	Evaluation of radiation database for diagnostics /control materials, by fission reactor		Test by A-FNS
	Compilation of fusion materials handbook			
	Design & construction of A-FNS			Operation of A-FNS

Functional Breeding Materials (Neutron breeder & Tritium Multiplyer)	(15)Q: Optimization of production and recycling of functional breeding materials ----- (18)Q: Evaluation & production of irradiation resistant Div materials ---- (18)Q: Securement technology for lithium -----	------> (22) (23)Q: Irradiation effects by fission reactor ------- --> -->	------------------> (30) ------------------> (30) (30)Q: Irrad. test by A-FNS →(35) --> (35)
Divertor Materials	(15)N/U: Irradiation effect by fission reactor - (18)Q/N/U: Development & evaluation of irradiation resistant materials ----	--> (26) --->	 --> (35)
Materials for diagnostics & Control	(15) Q/S: Database construction of irradiation effects →(19)	(20)J/N/U: Evaluation of irradiation resistant materials (35) ----	--> (35)
Others	(15) Q/N/U: Compilation of fusion materials handbook →(19)		
Fusion Neutron Source (FNS)	(15) Q: Design & construction of A-FNS	-->	------------------> (30) (30) Q/U: Operation of A-FNS →(35)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ 2035~
9. Safety	Study toward safety regulation → Formulation of Safety regulation Organization of engineering issues(Establishment of failure scenario, Evaluation of plasma effects on equipments in vessel) Safety analysis / evaluation (Development of safety analysis code) → V & V → Evaluation of safety Assess. for regulation on environmental Tritium	Evaluation of released Tritium behavior and decision of safety policy	
Safety Regulation	(15)S/D: Safety feature of Demo (Evaluation by existing codes) →(16) (17)S/D: Safety feature of Demo (Decision of safety policy) →(19)	(20)S/D: Safety feature of Demo (Analysis based on the safety policy) →(26) (20)TF/S: Preliminary study on safety regulation →(26)	(27)A: Decision of regulation policy on safety →(31)
Organization of Engineering Issues on Safety	(15)S/Q/I/N/U/D: Establishment of failure scenario ----	--> (26)	
Safety Analysis & Evaluation	(15)S/Q/D: Development of safety analysis code ---	--- (20)Q/U/S: V&V (Chemical reaction, dust behavior analysis, etc.) →(26) (20)S/D: Safety analysis of Demo plant ------------- (20)S/D: Decision of design criteria consistent with safety policy in conceptual design →(26)	--> (31) --> (31) (27)S/D: Decision of design criteria consistent with safety policy in engineering design →(31)
Evaluation of Environmental Behavior of Tritium	(15)S/Q/N/U: Assessment & study on restriction target of environmental Tritium → (19)	(20)S/U/N/D: Evaluation of volume of release in operation & accident, and development of control technique for containment ----	--> (34)

Phases of Action

Black: Kick off of Items
Red : Close of items

	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ … 2035~
10.Availability & maintenance	Decision of reactor concept and maintenance scenario / Selection of R&D issues Study of back-end issues (from about 2019) Development & accumulation of maintenance technology	Minimization of outage due to maintenance Study of back-end issues (continued) Development & accumulation of maintenance technology (continued)	Development & accumulation of maintenance technology (continued) Middle scale R&D Tech.dev. for 200MGy Facility for maintenance technology development in large scale
Design of Demo	(15)S/D/Q: Pre-decision of maintenance scenario→ (17) (15)S/D/Q: Decision of reactor concept & main parameters→ (17) (17)S/D/Q: Investigation & selection of R&D issues for maintenance → (18)	(20)S/D/Q: Study on work sequence & outage for maintenance→ (24) (25)S/D/Q: Review of maintenance scenario→ (26)	
Back-end Study	(18)S/U/D: Study of back-end scenario → (19)	(20)Q/U/D: Study on regulation for recycling of Radioactive waste→ (22) (23)Q/D/A: Decision of regulation for recycling of Radioactive waste (toward legal restriction) → (26)	
Development & accumulation of maintenance technology	(17)D: Handling & inspection technologies of nuclear facilities→ (19)	(20)S/Q/D: Assessment of remote maintenance & inspection technology→ (21) (22)D: Handling & inspection of nuclear facilities→ (24) (25)S/D: Organization of remote maintenance & inspection technology→ (26) (25)S/Q/D: Investigation of failure rate DB --------	(30)Q/D: Middle scale R&D of maintenance technology→ (34) (30)Q/D/U: Development of functional materials & equipments→ (34) --> (34)
New Facility			(29)Q: Facility for maintenance technology development in large scale; Preliminary design→ (30) Manufacturing design→ (32) Construction → (36)

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
Black: Kick off of Items Red : Close of items	2015	2020~	2025~ … 2035~
11.Diagnostics & Control	Study of stability limit & control parameters	Verification of stability limit & control parameters by JT-60SA	Establishment of proven DB by ITER/JT-60SA, etc.
	Selection of candidate diagnostics Establishment of development framework	Development of candidates for diagnostics , Establishment of reliability by ITER/JT-60SA, Decision of diagnostics specifications	
	Preset of operation parameters & margin	Verification of controllability & margin in the operation parameters	
	Development of operation simulator	Verification & improvement of operation simulator by ITER / JT-60SA	
		Development, operation test & improvement of real-time control system using JT-60SA	
Prediction by Theory, Existing / International Experiments Inspection by Experiments in Japan	(15)Q/大/S: Understanding of theoretical stability limit→ (19) (15)Q/N/U/S: Study of controllable parameters→ (19) (17) Q/U: Equilibrium simulation using magnetic probes positioned distantly→ (19)	(20) Q/N/U/I/S: Verification of stability limit & controllable parameters→ (26) (20) Q/U/I/S: DB of control performance in ITER/JT-60SA (methods, reliability, etc.) & response time---- (20) Q/U: Verification of equilibrium by magnetic probes positioned distantly → (26) (27) Q/U/I/S: Establish. of op. & maintenance DB of diagnostics by ITER/JT-60SA ----	---> (35) ---> (35)
Development of Diagnostics	(15) Q/N/U/S: Classification & selection of diagnostics consistent with Demo design→(19) (16) Q/N/U/TF: Establishment of development framework of diagnostics incl. radiation test → (19)	(20) Q/N/U/D/S: Decision of candidate diagnostics & development→ (26) (20) Q/N/U/D/S: Plasma test, radiation test, lifetime inspection ----	(27) Q/N/U/D/S: Development & evaluation of candidate diagnostics→ (35) ---> (35) (30) Q/N/U/D/S: Decision of diagnostics spec. →(35) (30) Q/N/U/D/S: Development & trial test of maintenance of diagnostics → (35)
Evaluation of operation parameters and margin	(16) Q/N/U/S: Preset of operation point & allowable range → (19)	(20) Q/N/U/S: Verification of operation point & allowable range → (26)	(27) Q/N/U/S: Decision of operation point & allowable range → (35)
Prediction (off-line)	(16) Q/U: Development of plasma operation simulator→ (19)	(20) Q/U/S: Verification of plasma operation simulator→ (26)	(27) Q/U/D/S: Improvement of plasma operation simulator→ (*)
Real-Time Control System	(16) Q/U: Development of real time controller for JT-60SA→ (19)	(20) Q/U: Operation of real time controller ------- (20) Q/N/U/S: Verific. & improv. of 1st principle type code, simulator, real time control→(26) (20)Q/N/U/S: Development of tools for learning & prediction→ (26)	---> (35) (20) Q/U/S: Verific. of performance (accuracy reliability) of int. code, control simulator→ (35) (30) Q/U/S: Decision of specification for real time control→ (35)

Black: Kick off of Items
Red : Close of items

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ 2035~
12. Cooperation with Society	Policy, preparation & planning for HQ Study of Education framework & program Cooperation with society for Fusion roadmap & Demo design activity	Establishment of HQ Forwarding of outreach operation Outreach Education Cooperation with society for site decision of Demo plant	Cooperation with society for Demo construction & operation
Establishment of Outreach Head Quarter (HQ)	(16)TF/S/Q/N/F/A: Establishment of concept of outreach HQ→ (19) (20)TF/S/J/N/F/A: Planning of fusion outreach operation→ (20)	(20)TF/S/Q/N/F/A: Establishment of fusion outreach Head Quarter→ (20) (20)HQ/TF/S/Q/N/F/A: Forwarding of fusion outreach operation ----	---> (35)
Development of Human Resources for outreach operation	(18) TF/S/Q/N/F/A: Study of framework & program for education→ (19)	(20)HQ/TF/S/Q/N/F/A: Education for outreach operation ----	---> (35)
Action for Cooperation with Society	(16)TF/S: Cooperation with society for Fusion roadmap & Demo design activity→(19)	(20)HQ/TF/S: Cooperation with society for site decision of Demo plant→ (26)	(27)HQ/TF/S: Cooperation with society for Demo construction & operation→ (35)

Phases of Action

Black: Kick off of Items
Red : Close of items

Phases of Action	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ / 2035~
13. Helical System	Demonstration of high performance plasma	Demonstration of high performance plasma	Demonstration of SS high performance plasma
	Specific plant engineering in Helical system ; study & demonstration of possibility	Specific plant engineering in Helical system ; study & demonstration of possibility	Engineering design of Helical plant
	Conceptual design ogf Herical plant	Conceptual design ogf Herical plant	
	Establishment of simulation technologies	Establishment of simulation technologies	
		Construction of numerical plant experiment	Construction of numerical plant experiment
Helical Plasma	(17)N/U: Demo. of high performance plasma ----	---> (25)	
	(15)N/U: Reduction of thermal load on Div and particle control ----	---> (25)	
	(15)N/U: Transport & high energy particle Confinement ----	---> (25)	
		(20)N/U/Q: Demonstration of SS plasma & plasma wall interaction ----	--->(35)
Plant Engineering & Plant Design	(15)N/U: Engineering feasibility of Helical plant by 3D analysis→ (19)		
	(15)N/U: Engineering feasibility of large & high field SC helical magnet---	---> (25)	
	(15)N/U: Engineering feasibility of long life liquid cooling blanket ----	---> (25)	
	(15)N/U: Development of low activation structure materials ----	---> (25)	
	(15)N/U: Devel. of plasma facing component with high heat load & related materials ----	---> (25)	
	(15)N/U: Conceptual design of Helical plant -------	---> (26)	(27)N/U/D: Eng. design of Helical plant → (35)
Numerical Plant Experiment	(15)N/U/Q: Simulation of elemebtary physics process ----	---> (26)	
	(15)N/U/Q: Simulation of Sophisticated physical binding & layer biding ----	---> (26)	
		(20)N/U: Const. of numerical plant exp.--------------	---> (30)

Phases of Action: Basic design of concept (2015–2020~) | Conceptual design (2020~–2025~) | Engineering Design (2025~–2035~)

Black: Kick off of Items
Red : Close of items

	2015	2020~	2025~	2035~
14. Laser Fusion	Development & inspection of divertor simulation code (2015–2035~) Conceptual design of divertor & establishment of operation scenario (~2017–2025) Demonstration of fuel cycle system by ITER (~2022–2035~) Development of elemental technologies for fuel system (2015–2025) Const. & demo of facility for handling of huge T (2025–2035~) Development of candidates for diagnostics , Establishment of reliability by ITER/JT-60SA, Decision of diagnostics specifications (2020–2035~)			
Comprehensive Understanding on Material – Plasma Interaction	(16)C1/U/N: Numerical modelling of material wear by plasma ---- (16)C1/U/N: Model experiment of material wear by plasma ---- (16)C1/U/N: Detailed design of material test facility→ (20)	---> (27) ---> (27)		
Development of Liquid Metal Wall	(16)C1/U/N: Detailed design of basic exp. facility for liquid metal wall → (20)	(25)C1/U/N: Test by basic experiment facility for liquid metal wall ----	-------------------> (29)	
Pellet Production & Injection Technology	(18)C1/N/U/D: Detailed design of pellet production system→ (19) (18)C1/N/U/D: Detailed design of pellet injection system→ (19)	(20)C1/N/U/D: Construction of mass-production system for pellets→ (23) (20)C1/N/U/D: Construction of pellet injector →(25)		
Stock & Handling Technology of Tritium	(16)C1/C5/N/U/Q: Detailed design of Tritium stock & providing system→ (18) (16)C1/C5/N/U/Q: Conceptual design of Tritium recycle system→ (18) (19)C1/N/U/Q: Detailed design of Tritium recycle system→ (22)	(19)C1/N/U/Q: Detailed design of Tritium recycle system→ (22) (22) C1/C5/N/U/Q: Construction of Demo facility of fuel stock & providing system→ (27)		
Diagnostics under Extreme Condition	(15)C1/**C5**/N/U: Investigation of laser-produced extreme condition→ (18) (18)C1/N/U: Offer of laser-produced extreme condition ----	--->	---> (35)	

Phases of Action

Black: Kick off of Items
Red : Close of items

	Basic design of concept	Conceptual design	Engineering Design
	2015	2020~	2025~ / 2035~
Appendix Development of Specific Issues in Laser Fusion	Plasma physics experiment (FIREX-I) Demonstration of self-ignition (FIREX-II) [spans into Conceptual design]	Test of repeatedly process in plant engineering [spans into Engineering Design]	Design of Laser Fusion Demo
Fusion Fuel Plasma	(15)C1/N/U: Basic experiment of fusion fuel plasma→ (17) (16)C1/N/U: Consideration on Int. collab.→(18) (19)C1/N/U: Preparation of int. collaboration → (22) (17)C1/N/U: Numerical design of self-ignition fusion fuel plasma → (21)	(22)C1/N/U: Numerical design of high gain fusion fuel plasma ---- (20)C1/N/U: Demonstration of self-ignition → (26)	--------------------> (29)
Test Facility for Repeatedly Process in Plant Engineering	(16)C1/N/U/D: Conceptual design of repeatedly process test facility→ (18) (18)C1/U/D/QW/N: Detailed design of 20 kJ/10 Hz laser→ (19) (18)C1/N/U/D: Detailed design of mass-production facility for pellets→ (19) (18)C1/N/U/D: Detailed design of pellet injector→ (19) (15)C1/U/N/D: Detailed design of pellet tracking system→ (22)	(23)C1/U/N/D: Construction of pellet tracking system ---- (23)C1/N/U/D: Repeatedly laser irradiation test - (20)C1/U/D/QW/N: Construction of 20 kJ/10 Hz laser→ (25) (20)C1/N/U/D: Construction of mass-production facility for pellets→ (23) (20)C1/N/U/D: Construction of pellet injector → (25)	----------------> (28) ----------------> (28)
Plant Engineering	(16)C1/U/N: Comprehensive understanding on material – plasma Interactions ---- (16)C1/N/U/D: Detailed design of basic experiment facility for liquid metal wall→ (20) (16)C1/N/U: Detailed design of material test facility→ (20) (19)C1/N/U/D: Detailed design of Tritium recycling system→ (22) (19)C1/N/U/D: Construction of Tritium stock & supplying system→ (21)	--> (27) (22)C1/C5/N/U: Connection of Tritium stock & supplying system to target production → (25) (22)C1/C5/N/U: Construction of Tritium recycling system→ (25) (21)C1/N/U: Construction of basic experiment facility for liquid metal wall→ (24) (24)C1/N/U: Material test with radiation → (27) (25)C1/N/U: Test by basic experiment facility for liquid metal wall→ (29)	