International Development Team

Work Breakdown Structure for the Prelab phase

Benno List, DESY

13th IDT WG2 Meeting

6.4.2021

Accelerator activities at ILC Pre-lab phase

Technical preparations /performance & cost R&D [shared across regions]

- SRF performance R&D
- Positron source final design and verification
- Nanobeams (ATF3 and related): Interaction region: beam focus, control and Damping ring: fast kicker, feedback
- Beam dump: system design, beam window, cooling water circulation
- Other technical developments considered performance critical

Technical preparation

Final technical design and documentation [central project office in Japan with the help of regional project offices (satellites)]

- Engineering design and documentation, WBS
- Cost confirmation/estimates, tender and purchase preparation, transport planning, mass-production planning and QA plans, schedule follow up and construction schedule preparation
- Site planning including environmental studies, CE, safety and infrastructure (see below for details)
- Review office
- Resource follow up and planning (including human resources)

Engineering Design Report (EDR)

Preparation and planning of deliverables [distributed across regions, liaising with the central project office and/or its satellites]

- Prototyping and qualification in local industries and laboratories, from SRF production lines to individual WBS items
- Local infrastructure development including preparation for the construction phase (including Hub.Lab)
- Financial follow up, planning and strategies for these activities

Mass-production

CE, local infrastructure and site [host country assisted by selected partners]

- Engineering design including cost confirmation/estimate
- Environmental impact assessment and land access
- Specification update of the underground areas including the experimental hall
- Specification update for the surface building for technical scientific and administrative needs

Civil engineering

WBS Structure for Prelab-Phase

- WBS: “A deliverable-oriented hierarchical decomposition of the work to be executed by the project team” [PMBOK]
- Different project phases are projects of their own, with their own WBS:
  - WBS for Technical Design Phase TDP
  - WBS for Prelab phase
  - WBS for construction phase
- In each phase, prepare WBS for next phase
  - Define WBS for prelab phase now
  - Define construction project WBS in prelab phase
- Guiding principles of a WBS:
  - Deliverable-oriented
  - Compatible with work organisation

- **What are the deliverables in the Prelab phase?**
  - **Final deliverables: construction-ready design, project plan, cost book**
  - **Intermediate deliverables: Component counts, power estimates, requirements, design criteria…**
  - **EDR is a human-readable summary of these design deliverables**

Deliverables

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Civil engineering

Deliverables of the Prelab-Phase -> And who does it

- Accelerator design*
  - Overall integrated design -> AD&I
  - Sources, DR, RTML, ML, BDS -> Acc. areas
  - Artefacts: Lattice, beam parameters, system description, imput for CFS design criteria (requirements), component counts, design for specific components, availability data,
- Technical components design*
  - Magnets, vacuum, diagnostics, LLRF, controls, dumps, collimators, survey and alignment, installation… -> Technical system groups
  - Artefacts: Component designs, technical data, prototypes, subsystem design, component unit costs, production plans, requirements
- SCRF design and prototypes*
  - Cryomodules, cavities, couplers, tuners, SC quad, BPM, HLRF (klystrons, modulators, PDS), cryogenics -> SCRF groups
  - Artefacts: Component designs, technical data, prototypes, subsystem design, component unit costs, subsystem costs, production plans, requirements
- Conventional facilities and site design*
  - Civil engineering (caverns, tunnels, surface buildings) design
  - Technical infrastructure (el. Power, water, HVAC, network, transport, safety, …) designs
  - Site design (Campus, transport, water, power lines, housing…)
  - Artefacts: Requirements / design criteria, construction plans, costs, schedule, schematics, env. impact assessment,
- Project plan*
  - Cost estimate, cost book, project implementation plan, project schedule, construction project WBS and organisation, logistics plan, legal framework… -> project office
- Engineering plan
  - System architecture, Requirements, Risks, CAD model, Technical Documentation, QA plan…
- Outreach & PR material
  - Web site, videos, lectures, exhibitions… -> Outreach team

* = “based on TDR, consolidated and updated”

Proposed 1st level elements of a Prelab WBS

THE ACCELERATOR (PRODUCT)

- Accelerator Design and Integration
  - Design the accelerator, its accelerator subsystems and their subsystem specific components
  - Design accelerator components (except SCRF/HLRF), including instrumentation and controls (Technical systems)
- SCRF (incl. HLRF) Technology
  - Design all SCRF and HLRF components and the cryogenic system, for the ML and other accelerator subsystems, produce prototypes, qualify vendors and hub labs, establish/qualify production sites and companies
- Conventional Facilities and Siting
  - Design all conventional facilities and the site

CROSS-SECTIONAL ACTIVITIES

- Project Management and Legal Affairs
  - Perform project management of the prelab phase (cost, schedule, …)
  - Prepare Project Management of the Construction phase
- Systems Engineering and Quality Management
  - Support systems engineering processes of prelab phase (documentation, CAD, requirements, …)
  - Prepare Systems Engineering processes for construction phase (all of the above, risk management, quality management, …)
- Safety and Environment
  - Manage all safety, health, radiation and environmental protection issues
- Outreach and Public Relations

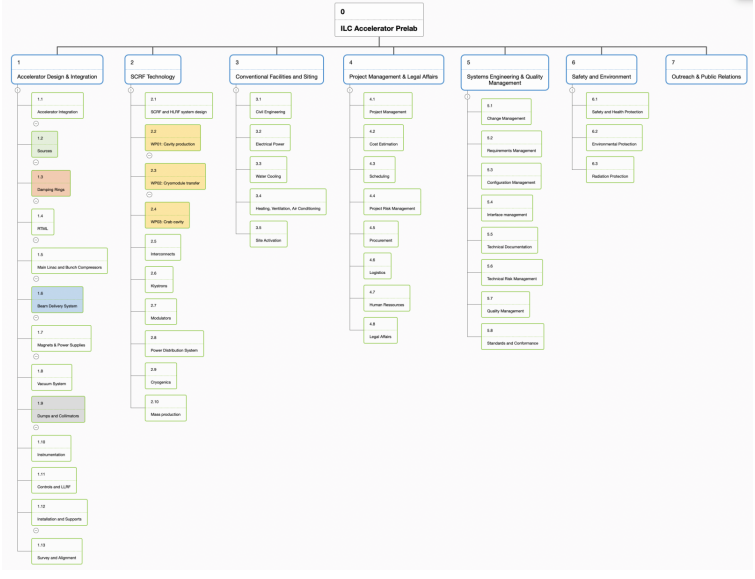
Accelerator Areas and Technical Systems

- RDR: Structured along technical systems (magnets, vacuum, instrumentation…)
- TDR: Structured along accelerator areas (sources, damping rings, main linac…)
- Both are needed:
  - Accelerator design focusses on overall system design, beam dynamics etc
  - Technical systems provide component design and costs, **and** concept / design of specific system:
    - Magnets and power supplies: Powering concept, cable dimensions, distribution of power supply stations…
    - Instrumentation: Overall concept for beam steering etc
    - Controls and LLRF: Design of control system, LLRF system, data acquisition…

- Decision: Separate WBS groups for
  - Accelerator design and integration
  - Technical systems?
- AD&I has clearly defined deliverables: Integrated design of whole accelerator complex
- Technical systems: Overall deliverable is sum of all subsystem deliverables?
- WBS structure should reflect deliverables, and responsibility / autority
- Proposal: **Keep AD&I and technical systems under one roof**, with one coordinator
- SRF (+HLRF): Of central importance for the project: keep as separate WBS group

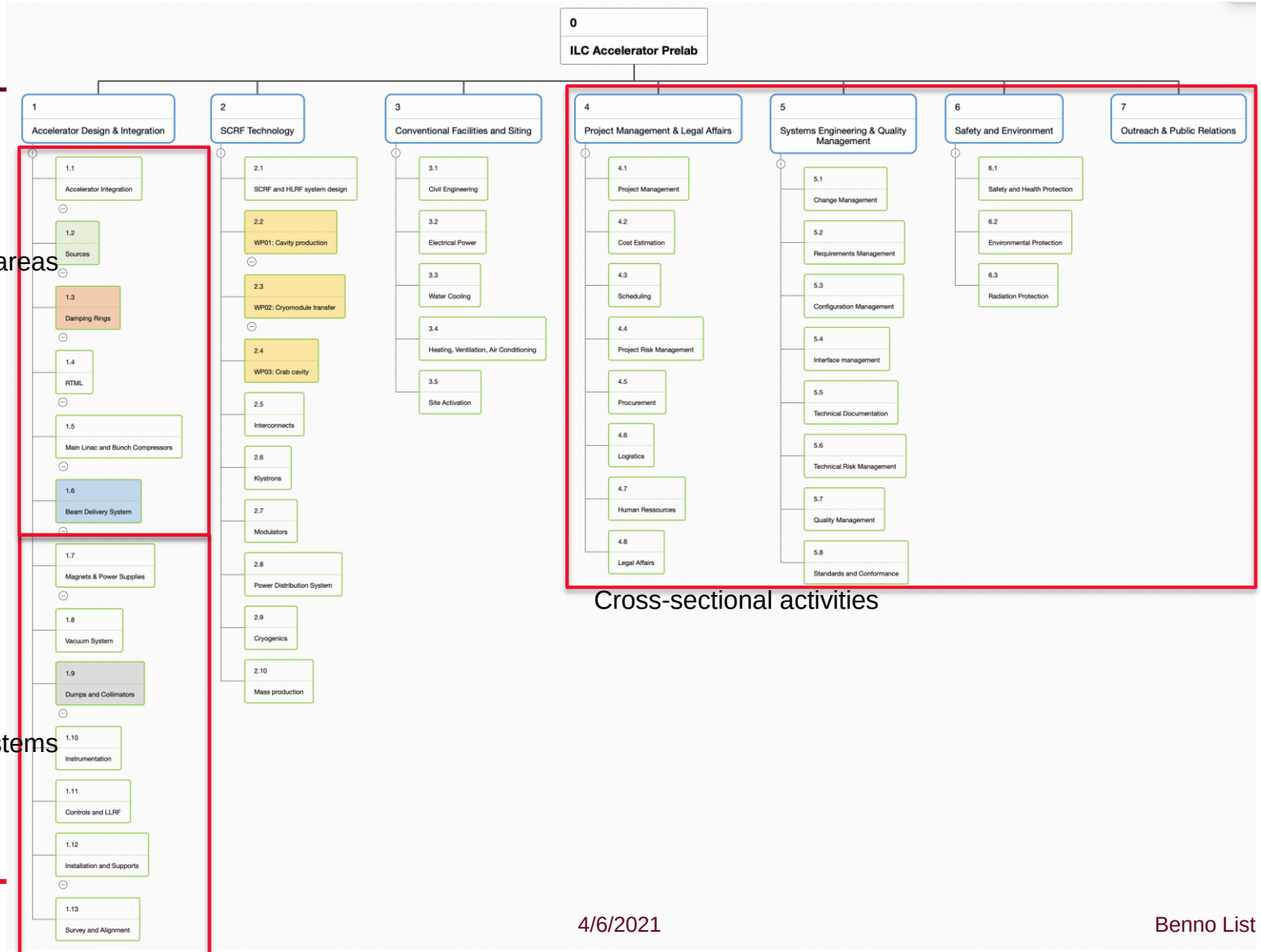
Technical preparation and engineering design

- Technical preparation plan focusses largely on R&D and prototyping, with some system design work packages (DR) and some component designs (crab cavity, main dump, photon dump)
- Augment the 18 TPP work packages already defined with additional emgineering design work packages in one structure



Accelerator areas

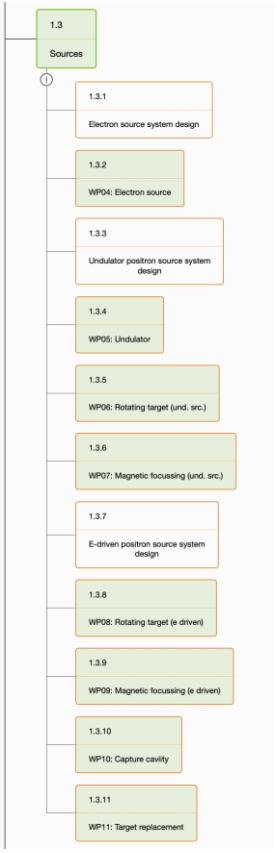
Technical systems

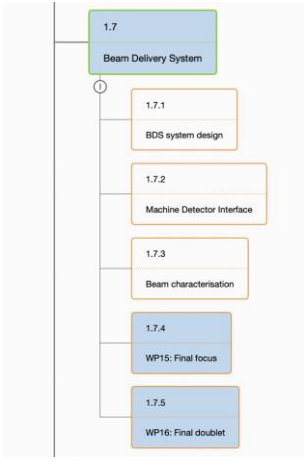


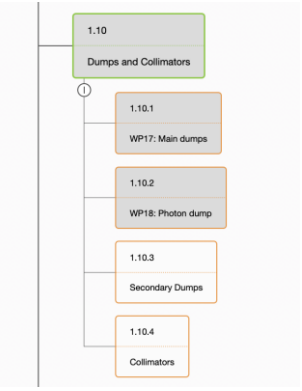
Cross-sectional activities

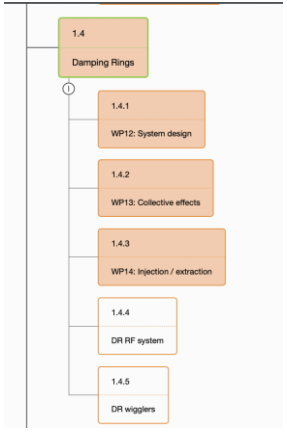
Existing TPP work packages

- Area systems “Damping ring” and “Beam delivery system” from TP plan remain, some additional WPs are added
- Area systems “electron source” and “positron source” share many aspects (booster design, transfer tunnels etc)
  - unite under one roof?
  - Add “system design” work packaqges that design all beamlines, lattice, make simulations etc
- Area system “beam dump” continues as technical system “dumps and collimators”



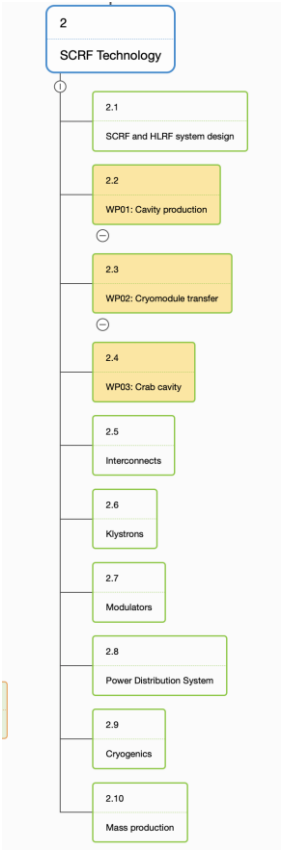


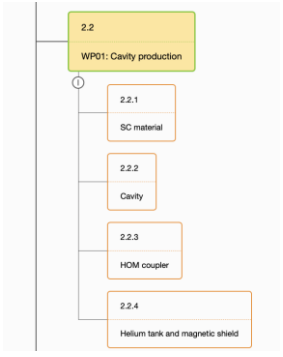


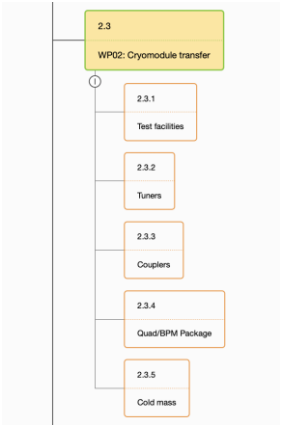


SCRF Technology

- Central to project's success
- WP01 and WP02 are large (in terms of scope and ressources), could be decomposed in smaller packages for better definition
- Add
  - Overall system design (complete RF units and cryo strings)
  - Design of interconnections
  - HLRF packages: Klystron, modulator, power distribution (waveguide) system
  - Cryogenics
  - Mass production as separate WP?
  - Includes modules for source 5GeV boosters!
- Keep "Main Linac and Bunch Compressors" as separate WP in AD&I: design of BC, abort lines, beam dynamics of ML







Scoping statements and deliverables

- For each WBS item, describe the scope of work to be done, the deliverables and their state
- For deliverables, provide a list
- Technical area work packages –
  a rough proposal, to be discussed and refined by responsible subgroups, as far as they exist!

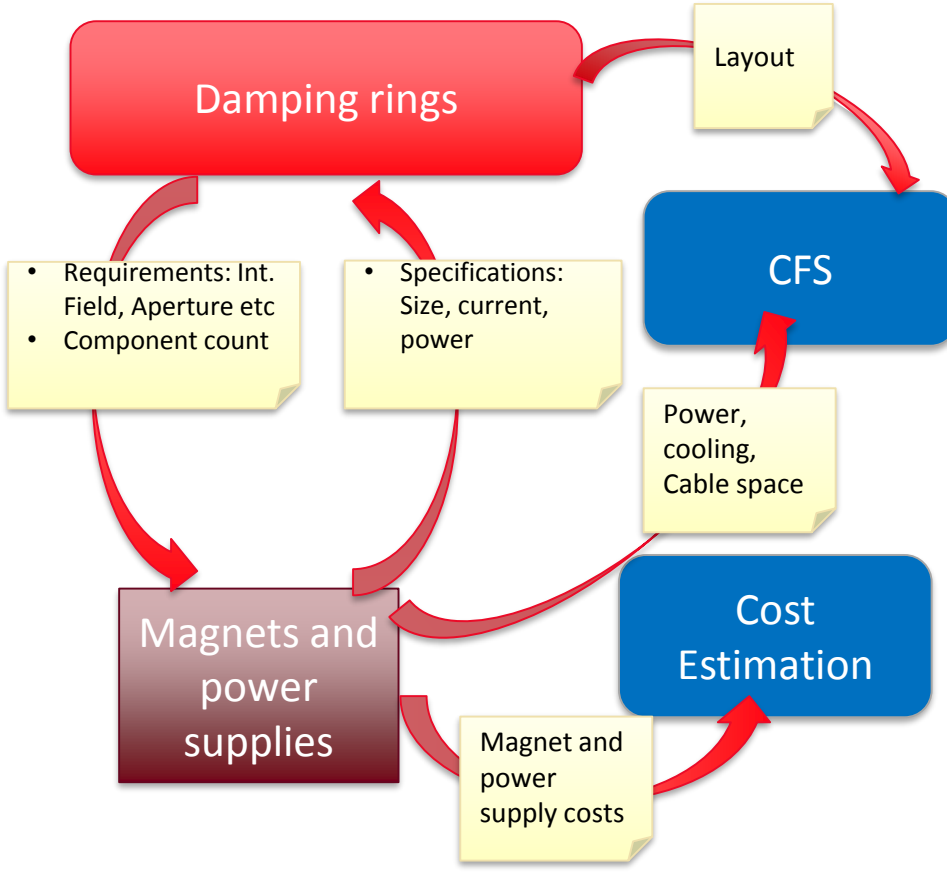
# ▲	Code	Title	Scoping statement	Deliverables
0		▼ ILC Accelerator Prelab		
1	1	▼ Accelerator Design & Integration	**Design the ILC accelerator as a whole**	**Key performance figures; integrated lattice; overall machine layout; input to cost estimate; CFS requirements; EDR volume "accelerator design"**
2	1.1	▶ Accelerator Integration	**Integrate the accelerator design, coordinate work of the accelerator areas and technical system work packages**	**Integrated ILC lattice; Overall system design**; Chapter for EDR
8	1.2	▶ Sources	**Design the electron and positron source systems, with prototypes of critical items**	Source system lattices; Sources system design; Sources performance specification; component requirements and specifications; Component counts; Design and costs for sources specific components; Prototypes of critical items; Chapter for EDR
20	1.3	▶ Damping Rings	**Design the DR system**	**DR system lattice; DR system design; DR performance specification; component requirements and specifications; Component counts; Design and costing of DR specific components (RF system, wigglers, kickers); Chapter for EDR**
26	1.4	▶ RTML	**Design the RTML system**	**RTML system lattice; RTML system design; RTML performance specification; component requirements and specifications; Component counts; Chapter for EDR**
30	1.5	▶ Main Linac and Bunch Compressors	**Design the main linac system, including bunch compressors**	**ML&BC system lattice; ML&BC system design; ML&BC performance specification; component requirements and specifications; Component counts; Chapter for EDR**
33	1.6	▶ Beam Delivery System	**Design the beam delivery system and machine detector interface, including extraction line**	**BDS system lattice; BDS system design; BDS performance specification; component requirements and specifications; Component counts; Chapter for EDR; MDI specification; interrface specifications**

Technical system work statements

# ▲	Code	Title	Scoping statement	Deliverables
39	**1.7**	▶ **Magnets & Power Supplies**	**Design magnets, kickers and power supplies**	**Conceptual magnet designs and specifications; magnet and power supply cost estimates (unit and overall costs); power supply concept; cabling design; CFS reqiorements; Chapter for EDR**
44	1.8	Vacuum System	Design vacuum system	Conceptual layout of all warm vacuum sections; component specifications, counts and cost estimates; CFS requirements; Chapter for EDR
45	**1.9**	▶ **Dumps and Collimators**	**Design all beam dumps**	**Engineering layout of main dumps; conceptual layout of other dumps and collimators; Specifications; Cost estimates; CFS requirements; Chapter for EDR**
50	1.10	Instrumentation	Design instrumentation system	Overall instrumentation concept; component specifications and conceptual designs; instrumentation cost estimate; CFS requirements; Chapter for EDR
51	1.11	Controls and LLRF	Design the control and LLRF system	Overall control system and LLRF concept; component specifications and conceptual designs; cost estimate; CFS requirements; Chapter for EDR
52	**1.12**	▶ **Installation and Supports**	**Design the support system, installation procedures**	**Support conceptual design; installation plan; logistics plan (storage, transport); underground transport concept; Cost estimate; installation chedule; CFS requirements; Chapter for EDR**
55	1.13	Survey and Alignment		**Survey and alignment conceptual design; survey concept; Cost estimate; Survey schedule; CFS requirements; Chapter for EDR**

Relation between accelerator areas and technical systems

- Accelerator area work packages lay out the accelerator, plan lattice etc
- Component specifications go to technical system work packages
- Technical systems design / specify components and supporting system (e.g. power supplies)
  - Specifications go back to accelerator area groups (e.g. space requirements)
  - Cost information goes to cost estimation WP (attributes capture “DR” as accelerator area)
  - Requirements for electricval power, cooling water, rack space go to CFS



SRF Technolology work packages and work statements

- This is only a very rough proposal, should be formulated by SRF subgroup!
- Currently, WP01 and WP02 focus very much on R&D. Extend their mandate?

# ▲	Code	Title	Scoping statement	Deliverables
56	**2**	▼ **SRF Technology**	**Design and prototype the SRF and HLRF components and subsystems**	**Key performance figures; design of SRF and HLRF components and systems; input to cost estimation; CFS requirements; Prototype modules; EDR volume "SRF technology"**
57	2.1	SCRF and HLRF system design	Design complete RF units and cryo strings (for Main Linac, Bunch Compressors and 5GeV boosters in Sources)	Layout of RF units and cryo strings; CFS requirements; Chapter for EDR
58	**2.2**	▶ **WP01: Cavity production**	**Demonstrate cavity production readiness**	**Final cavity design; final surface treatment recipe; testing recipe; cost estimate; performance specification; 120 prototype cavities; Chapter for EDR**
63	**2.3**	▶ **WP02: Cryomodule transfer**	**Demonstrate cryomodule production readiness**	**Final cryomodule design; transportation plan; standards for cryomodule production and operation permit; plug compatibility interface soecification; cost estimate; 6 prototype cryomodules; Chapter for EDR**
69	2.4	WP03: Crab cavity	Design crab cavity system	Final crab cavity design; cost estimate; Chapter for EDR
70	2.5	Interconnects	Design cryomodule interconnects	Cryomodule interconnect design; cost estimate; Chaper for EDR
71	2.6	Klystrons	Design klystrons	Final klystron design / specs; cost estimate
72	2.7	Modulators	Design modulators	Final modulator design / specs; cost estimate
73	2.8	Power Distribution System	Design RF power distribution system	Final power distribution system design / specs; cost estimate; 6 prototype LPDS system
74	2.9	Cryogenics	Design cryogenic system	Cryogenic system design; cost estimate
75	2.10	Mass production	Qualify vendors for mass production	Set of qualified vendors

Conventional Facilities and Siting

- Scoping needs to be defined
- What is the deliverable at the end of the Prelab? Documents for Call-for-Tender? A prepared site ready for ground breaking, with all construction permits?

# ▲	Code	Title	Scoping statement	Deliverables
76	**3**	▼ **Conventional Facilities and Siting**		
77	3.1	Civil Engineering	Prepare designs ready for CFT of all tunnels, caverns, surface buildings and underground areas	Complete documentation for CFT
78	3.2	Electrical Power	Design electrical power network, from power grid to power [illegible]	Complete documentation for CFT
79	3.3	Water Cooling	Design water cooling system	Complete documentation for CFT
80	3.4	Heating, Ventilation, Air Conditioning	Design HVAC system	Complete documentation for CFT
81	3.5	Site Activation	Provide site for construction project, ready for ground breaking, including road access, electricity, and water for construction sites, Prepare plan for site infrastructure during construction and operation project (road, railsway and sea access, water, electricity)	

PLACEHOLDER

Project Management & Legal Affairs

- Manage the project during Prelab phase
- Plan the construction phase
- Provide processes and implement technical solutions: Costing, scheduling, logistics…

# ▲	Code	Title	Scoping statement	Deliverables
82	**4**	**▼ Project Management & Legal Affairs**	**Manage the Prelab activities and prepare project management of the construction project.**	**Management plans and technical solutions for all Systems Engineering and Quality Management processes; Project Implementation Plan**
83	4.1	Project Management	Manage the Prelab activities (including preparation of EDRs) and prepare project management of the construction project.	Construction project management plan; Construction project WBS
84	4.2	Cost Estimation	Prepare the cost estimate (cost book) for the construction project	Construction project cost estimate (including HR); cost book; Construction project cost management plan
85	4.3	Scheduling	Prepare a schedule for the construction project	Construction project schedule
86	4.4	Project Risk Management	Manage project risks during the Prelab phase and prepare project risk management for the construction project (in particular measures to handle schedule and cost risks for the central lab and in-kind contributions)	Prelab risk register; Risk management plan; Periodical risk assessments
87	4.5	Procurement	Prepare central procurement procedures for the construction project (i.e. international CFT for SRF equipment)	Procurement plan and directives
88	4.6	Logistics	Prepare logistics plan (transport and storage) for construction project, in Japan and overseas	Construction project logistics concept
89	4.7	Human Ressources	Manage HR during Prelab phase and prepare HR for construction project	Conatruction project hiring plan
90	4.8	Legal Affairs	Prepare MoUs, IKC agreements for construction project, prepare legal structure of central lab?	MoUs; IKC agreements; import permits; planning permits; site acquisition

IDT

Systems Engineering and Quality Management

- Perform Systems Engineering processes during Prelab phase (documentation, requirements, change management, CAD modelling, interface documentation…)
- Plan the construction project (PBS, requirements,…)
- Provide processes and technical solutions (Req. database, CAD systems, PLM system)

# ▲	Code	Title	Scoping statement	Deliverables
91	**5**	▼ **Systems Engineering & Quality Management**	**Provide Systems Engineering and Quality Management (central and in regional centres) during Prelab phase and prepare Systems Engineering and Quality Management plans with technical solutions for the construction project**	**Management plans and technical solutions for all Systems Engineering and Quality Management processes; Systems Engineering Management Plan**
92	5.1	Change Management	Perform change management during Prelab phase and prepare change management plan for construction project	Prelab and construction project change management plan
93	5.2	Requirements Management	Perform requirements management during Prelab phase and prepare requirements management plan and technical solution for construction project	Requirements database; requirements management plan; requirements database tool
94	5.3	Configuration Management	Develop PBS and prepare configuration management (inclkuding technical solution) for construction project	Construction project PBS (product breakdown structure); Construction project configuration management plan; Configuration database system
95	5.4	Interface management	Prepare interface documentation	Interface definition documents
96	5.5	Technical Documentation	Manage technical design documentation during prelab phase and prepare technical documentation for construction phase (plan and technical implementation)	Technical design documentation (TDD); Documentation plan; Document handling system
97	5.6	CAD Modelling	CAD modelling	CAD integration model; CAD model database; CAD modellling methods and standards
98	5.7	Technical Risk Management	Perform technical risk management during Prelab phase and prepare technical risk management plan for construction project	Technical risk analysis; Technical risk management plan; Periodical risk assessments
99	5.8	Quality Management	Prepare quality management plan for construction project	Construction project quality management plan
100	5.9	Standards and Conformance	Prepare and manage standards for the construction project (design rules, material qualities, applicable international norms and standards)	Register of applicable norms and standards

Safety and Environment, Outreach & PR

- Safety, Environmental Protection, Radiation protection need supervision within the project, during Prelab and in construction project – are separate work packages
- Provide guidance for all other work areas: Define policies, guidelines, applicable standards
- Enforce these policies within the project

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101	**6**	▼ **Safety and Environment**		**Safety and Environment Management Plan**
102	6.1	Safety and Health Protection	Define and enforce safety and health protection measures for population and workers throughout the project	Safety and health protection policies and guidelines; requirements for subsystems and components; fire protection plan; evacuation and rescue plan
103	6.2	Environmental Protection	Define and enforce environmental protection measures throughout the project	Environmental protection policies and guidelines; requirements for subsystems and components
104	6.3	Radiation Protection	Define and enforce radiation protection measures throughout the project	Radiation protection plan; standards / requirements for components
105	6.4	Earthquake and Disaster Protection	Define scenarios of natural disasters that the facility needs to survive; provide requirements and guidelines	Earthquake and natural disaster scenarios; Design rules, guidelines, specifications, requirements
106	7	Outreach & Public Relations	Inform the public about the ILC project	Project web site; brochures; press releases

Ressource Estimates

- Ressource estimates (work and money) must come from domain experts
- Where applicable, existing subgroups should provide estimates
- For others: Contact experts from the community
- Prelab must provide services and support for Project Management, Systems Engineering, Quality Management etc
  - Manage / support the Prelab phase itself
  - Plan the construction
  - Provide the technical solutions
  - What can be provided in-kind? How much can (or should) be decentralized? Needs discussion!

Conclusions

- Need a clear definition of the desired outcome of the Prelab phase, in particular for Civil Facilitiies & Siting
- CFS planning drives the process. Each step of the CFS process needs input from accelerator design, and makes certain changes very expensive or impossible
- The Prelab needs to organize the whole design process. R&D and engineering design should be part of a single design activity

Reserve

WBS and Documentation

- **Technical Design Documentation is organized along WBS**
- WBS: “A deliverable-oriented hierarchical decomposition of the work to be executed by the project team” [PMBOK]
- Different project phases are projects of their own, with their own WBS:
  - WBS for Technical Design Phase TDP
  - WBS for Prelab phase
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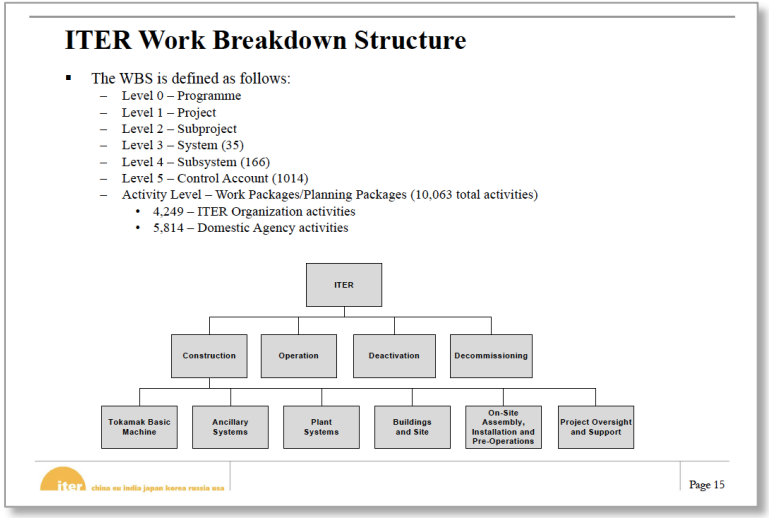
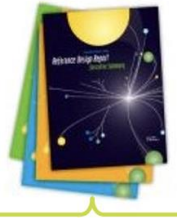


http://www-fusion-magnetique.cea.fr/etn-qpn/ws-scheduling/EFDA%20Conference%20-%20Scheduling.pdf

Example: ITER WBS.
Top Level ist programme phase

TDR and Technical Design Documentation

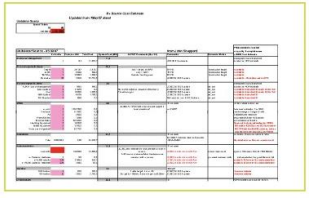


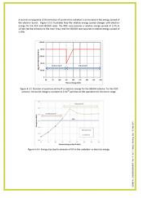
Technical Design Report (TDR) summarizes TDD for publication

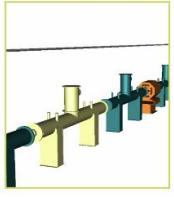
Technical Design Documentation (TDD) captures entire design efforts, results & rationale


Parameters


Specifications


Cost Estimation


Calculations


CAD Models


Design Summary

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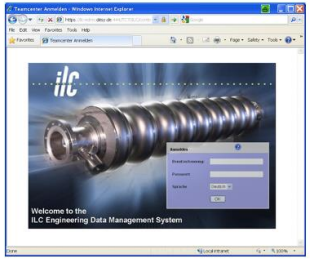
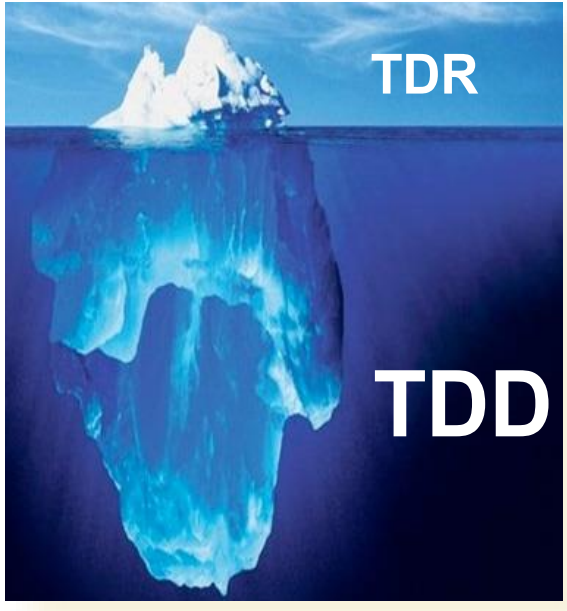
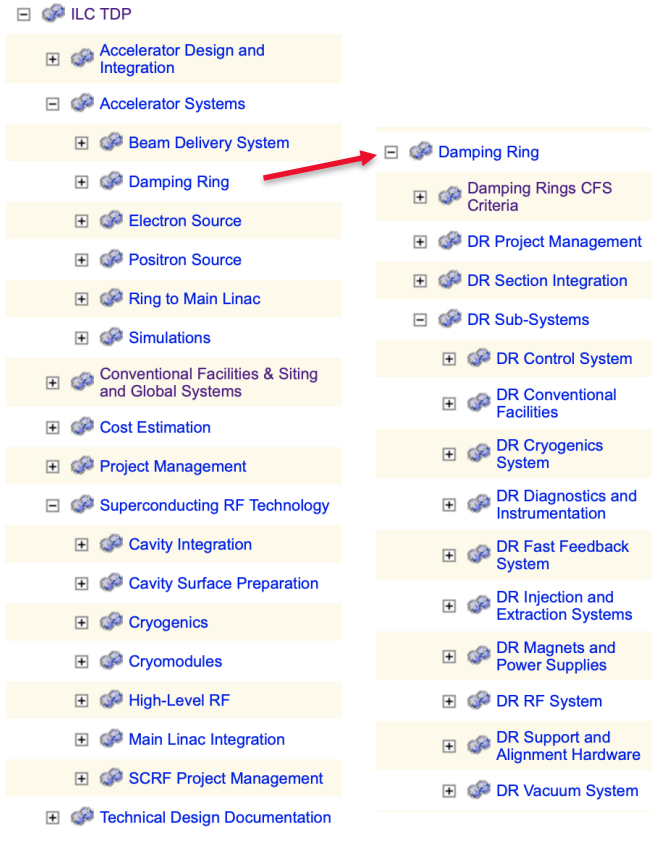


ILC-EDMS organizes the Technical Design Documentation, providing **structure**, **traceability**, **version & configuration mgt.**, and **change control**



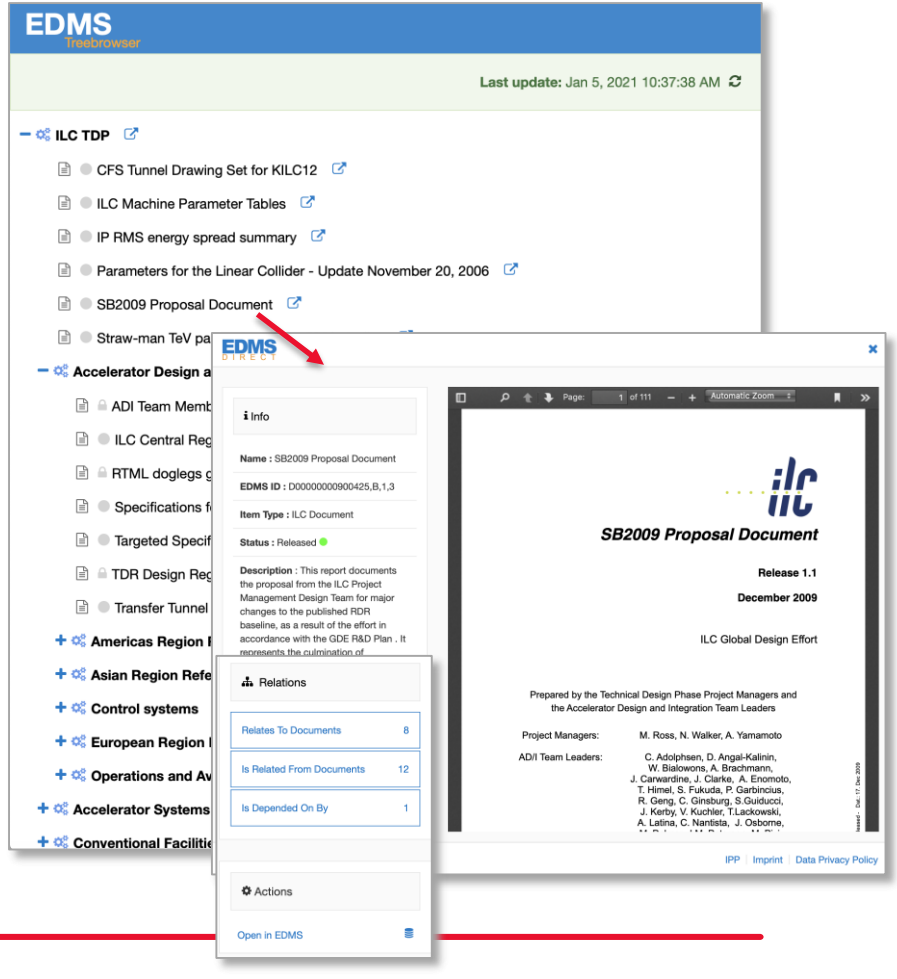
Structure of TDD from TDR (TDP-II) phase

- WBS for Technical Design Phase II (TDP-II) was never fully formulated
- Provisional WBS used to structure Design Documentation
- Main Structure:
  - Accelerator systems
  - SCRF technology
  - CFS
  - Some cross cutting activities:
    AD&I, Costing, Project management, Documentation
  - Other Technical Areas (magnets, vacuum, …) from RDR only present as parts of accelerator systems
- After Black December (12/2008), value engineering reduced to bare minimum, technical area groups outside SCRF non-existing -> No top-level element for Technical areas other than SCRF



Access to TDD

- New Web interface: https://edmsdirect.desy.de/treebrowser/ilc/
- Provides easy navigation through the TDR WBS and the associated documentation
- No log-in required
- Integrated preview of document PDF
- Documents are interrelated through links
- Link to EDMS interface also provided
- Some elements (costs!) are only available after log in with EDMS account, documents are visible only in full EDMS client



Design Register

- Design Register gives overview over design status of accelerator systems and their documentation
- Has a list of “mandatory documents” whose status is tracked
- Includes cross references
- Good practice: Prepare a list of artefacts / mandatory documents to be provided by the work packages
  - Drawings / CAD models
  - Schematics
  - Data sheets / specifications
  - Requirements
  - Calculations: Power, heat, costs, availability…
  - Procedure descriptions (installation, alignment, diagnostics, maintenance,…)

international linear collider

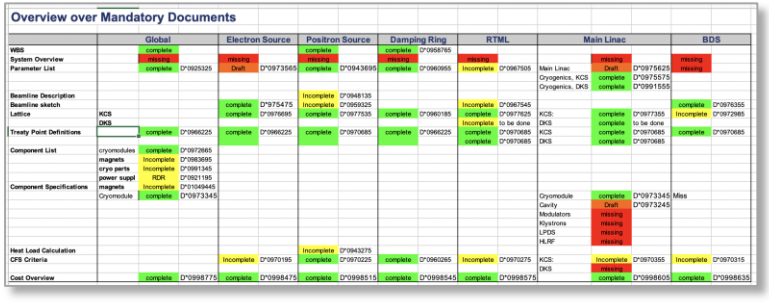
Design Register

Nicholas J. Walker, Benno List

Version	6.0	21.03.14
EDMS ID		D00000000959505

Revision History:

Version	Date	Author	Remark
0.9	17.06.2011	NW, BL	First Version
1.0	18.9.2011	BL	Updated: Added title page, added page on mandatory documents, updated DR references
2.0	02.11.11	BL	Updated: Added Electron Source Section
3.0	30.11.11	BL	Updated Mandatory documents section
4.0	01.02.12	BL	Updated Mandatory documents and references section
5.0	22.05.12	BL	Removed "Treaty points" sheet, updated all sheets
6.0	21.03.14	BL	Updated all sheets, WIP

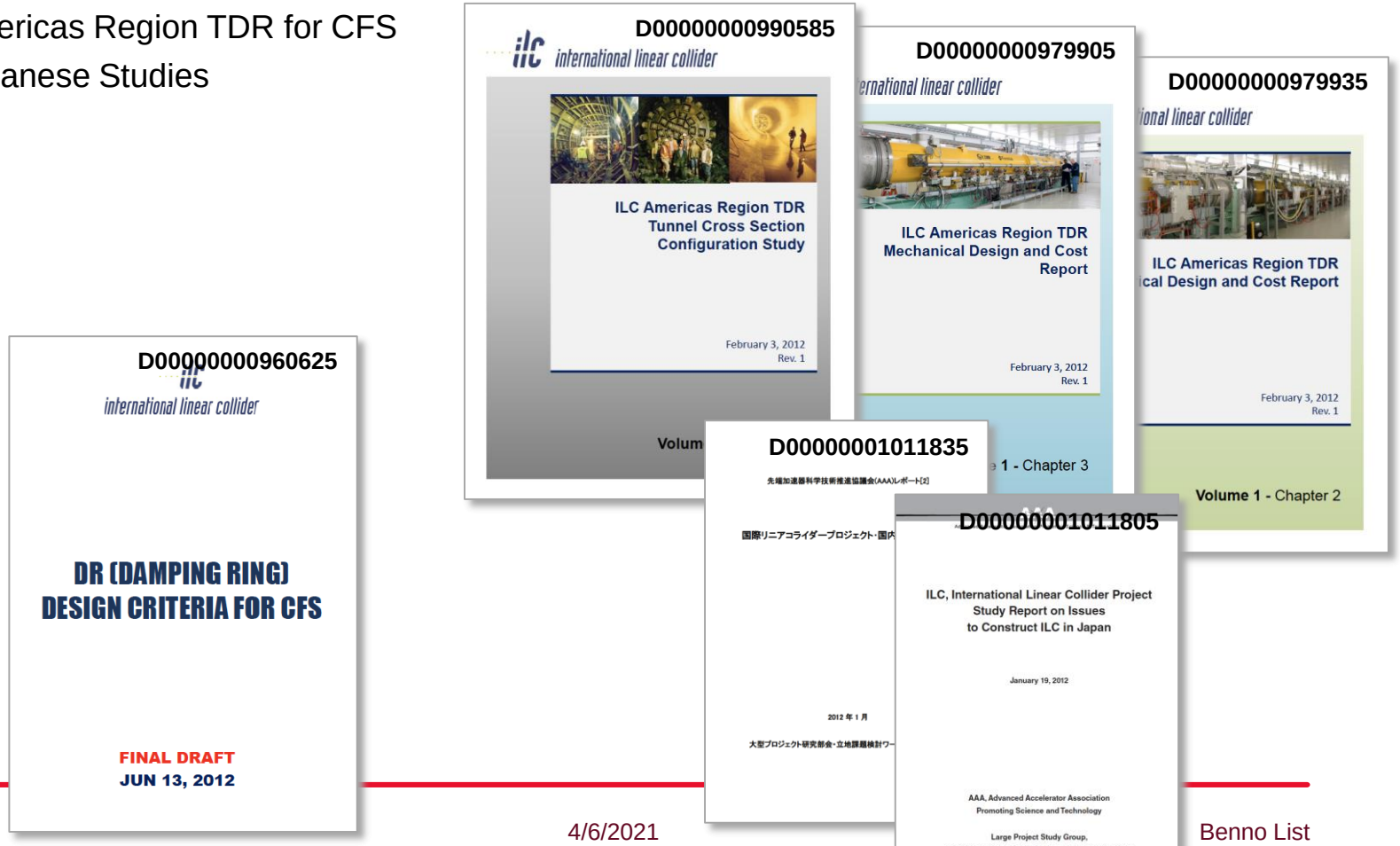


Overview over Mandatory Documents

	Global	Electron Source	Positron Source	Damping Ring	RTML	Main Linac	BDS
WBS	complete		complete	complete D*0958765			
System Overview	missing	missing	missing	missing	missing	missing	missing
Parameter List	complete D*0925325	Draft D*0973565	complete D*0943695	complete D*0960955	Incomplete D*0967505	Main Linac Draft D*0975625 Cryogenics, KCS complete D*0975575 Cryogenics, DKS complete D*0991555	missing
Beamline Description		Incomplete D*0948135					
Beamline sketch		complete D*975475	Incomplete D*0959325		Incomplete D*0967545		complete D*0976355
Lattice	KCS complete D*0976695 DKS	complete D*0977535	complete D*0977535	complete D*0960185	complete D*0977625 Incomplete to be done	KCS: complete D*0977355 DKS complete to be done	Incomplete D*0972985
Treaty Point Definitions	complete D*0966225	complete D*0966225	complete D*0970685	complete D*0966225	complete D*0970685 complete D*0970685	KCS complete D*0970685 DKS complete D*0970685	complete D*0970685
Component List	cryomodules complete D*0972665 magnets Incomplete D*0983695 cryo parts Incomplete D*0991345 power suppl RDR D*0921195						
Component Specifications	magnets Incomplete D*01049445 Cryomodule complete D*0973345					Cryomodule complete D*0973345 Miss Cavity Draft D*0973245 Modulators missing Klystrons missing LPDS missing HLRF missing	
Heat Load Calculation			Incomplete D*0943275				
CFS Criteria		Incomplete D*0970195	complete D*0970225	complete D*0960265	Incomplete D*0970275	KCS: Incomplete D*0970355 DKS missing	Incomplete D*0970315
Cost Overview	complete D*0998775	complete D*0998475	complete D*0998515	complete D*0998545	complete D*0998575	complete D*0998605	complete D*0998635

CFS documentation – Americas and Japan

- CFS Design Criteria for all subsystems
- Americas Region TDR for CFS
- Japanese Studies



Possible 2nd Levels

Accelerator Design and Integration

- Accelerator System Integration
  - Integrate accelerator subsystems, provide overall design and performance
- Sources
  - Design electron and positron sources and specific components (undulator, target regions, gun and laser system)
- Damping Rings
- RTML
- Main Linac and Bunch Compressors
  - Design Main Linacs and Bunch Compressors, based on SCRF design
- BDS

SCRF and HLRF Technology

- Cryomodules
  - Design all L-Band cryomodules for Main Linac, sources
  - Produce, transport to and test prototypes in Japan
- Cavities
- Cavity Material
- Tuners
- Couplers
- Quad / BPM package
- Klystrons
- Modulators
- Waveguide distribution
- Cryogenics

Possible 2nd Levels, cont'd

Project Management and Legal Affairs

- Project Management and WBS
- Costs
- Schedule
- Project Risks
- Procurement
- Logistics
- Human Ressources
- Legal Affairs

Systems Engineering and Quality Management

- Technical Documentation
- Requirements Management
- Technical Risks
- Quality management
- Configuration Management
- Standards and Conformance
- Change Management

Outreach and Public Relations

Safety and Environment

- Safety and Health Protection
- Environmental Protection
- Radiation Protection

Possible 2nd Levels, cont'd

Accelerator Components

- Magnets, Kickers and Power Supplies
- Vacuum
- Dumps and Collimators
- Instrumentation
- Controls and LLRF
- Installation, Supports and Girders
- Survey and Alignment

Conventional Facilities and Siting

- Civil Engineering
- Electrical Power
- Water Cooling
- Heating, Ventilation, Air Conditioning
- Site Activation

WBS Structure and Costing

- Cost estimate from TDR phase
  - WBS based – organized according to a WBS
  - Bottom-up – add number * unit costs of all components
- Final result was reported in a matrix form: (accelerator systems) X (technical areas)
- Cost estimate is based on WBS of construction project – need not be identical with WBS of prelab phase!
- In strictly WBS based costing, a “Magnets” work package would contain all costs for fabrication of magnets, ”installation” would contain costs of installation
  -> a parallel “Damping Rings” work package would not include these costs!
- Does not answer “**How much do the Damping Rings cost?”** or “**Which components drive DR costs?”**

- TDR WBS tried to answer these questions by a convention for levels 1/2 of WBS
  - 1: Accelerator systems
  - 2: technical areas
- Runs into many problems:
  - CFS: two systems in one tunnel
  - Same components in different systems: How to handle one-off costs, quantity rebates, spares
- Strength of a WBS based costing is 100%-rule: Every level is exactly the sum of its parts
- Reports on cost distribution are based on attributes, not on structure!
  - Distinguish atomic items from items that are summed up
  - Atomic items get attributes to allow all kinds of reports
  - Cost sharing over attributes must be possible (e.g. 75% BDS, 25% Sources)