

DRD1 Proposal

DRD1 document in preparation

<https://cernbox.cern.ch/s/BKQsu6oiuhPWDaa>

Structure of the document:

First 30 pages :

- **Scientific organization of DRD1 Collaboration**
- **Collaboration organization**
- **Resource and infrastructures**

From page 31

- **Research topics and Work plan**
 - 8 sections: one per Working Group
 - WorkPackages described in 7.2



DRD1

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DRD1 EXTENDED R&D PROPOSAL Development of Gaseous Detectors Technologies

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Abstract

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The document provides an overview of the state of the art and challenges for various detectors concepts and technologies, as well as a detailed list of R&D tasks grouped into Work Packages (WPs) that related to the strategic R&D programs to which funding agencies might commit, with related infrastructures and tools necessary to advance the technological goals, as outlined in the ECFA R&D roadmap. The main DRD1 document is structured into chapters, each describing the activity planned by the eight Working Groups (WG), which are the core of the future scientific organization. The current DRD1 proposal concentrates on the collaborative research program for the next 3 years.

On-line version: <https://cernbox.cern.ch/s/BKQsu6oiuhPWDaa>

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Geneva, Switzerland

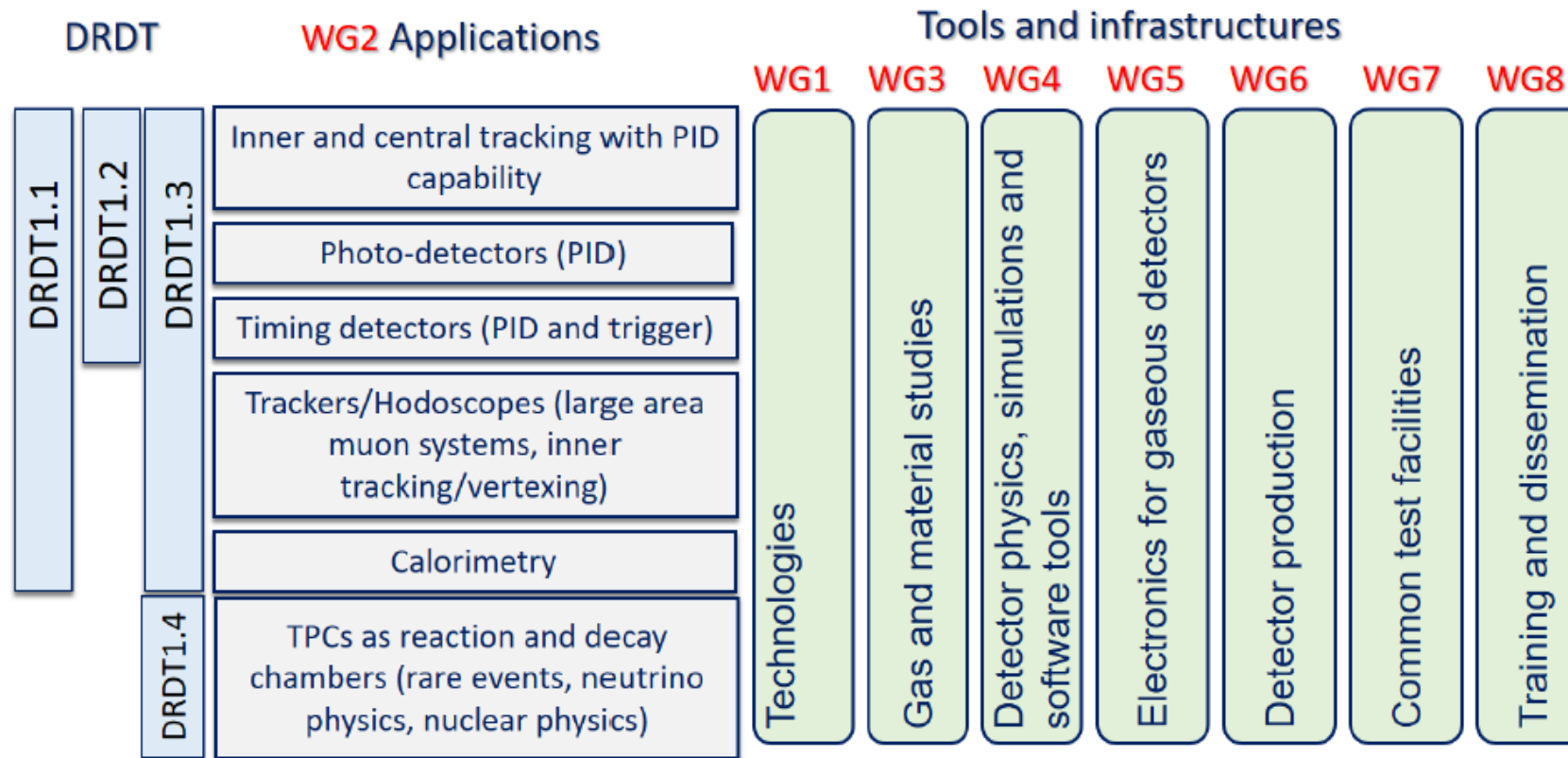
July 12, 2023

111 institutions in 4 continents expressed interest to join the DRD1 Collaboration

See more information at DRD1 2nd workshop [[link](#)]

DRD1 Scientific organization: Working groups

- **Structure in Working Groups, forum for scientific discussions, coordinated by conveners:**
 - aligned with the scientific program of the ECFA roadmap through the applications related to future facilities challenges, outlined by R&D Themes (DRDTs*), but also to the GSRs



Note: Applications Beyond HEP recently added

Working groups description in the proposal

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Working groups description in the proposal

2.1.1 WORKING GROUPS

The Collaboration will be organized into Working Groups (WGs), serving as the backbone of the proposed R&D environment and framework. WGs will support the development of novel technologies and the consolidation of existing ones.

They will facilitate the exchange of ideas and foster synergies between institutes, serving as a knowledge and technology hub. Additionally, they will be recognized as a scientific reference for the community. The proposed WGs are as follows:

- WG1: Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issues
- WG2: Applications
- WG3: Gas and Material Studies, and link to Novel Technologies
- WG4: Detector Physics, Modelling and Simulation frameworks
- WG5: Electronics for Gaseous Detectors
- WG6: Production and Technology Transfer
- WG7: Common Test Facilities and Infrastructures
- WG8: Knowledge Transfer, Training and Career

These Working Groups will guide new developments and provide support for the research activities of Collaboration members.

Working groups description in the proposal

Detailed (60 pages) description in section 7

“Detailed Description of Research Topics and Work Plan”

Reference	Description	Deliverable Nature
D3.1.1	Gas properties: drift velocity, diffusion for e- and ions, gain measurements, light emission, attachment, etc.	Common gas properties database
D3.2.1	Characterisation of new eco-friendly gases: gas properties, cross-section, etc.	New data for the integration in Magboltz and Garfield++ (collaboration with WG4)
D3.3.1	Longevity and ageing studies for different technologies	Report for a common approach
D3.3.2	Characterisation of material for the construction of detectors: material properties, compatibility, outgassing, etc.	Common construction material database
D3.4.1	Development of gas recirculation and recuperation systems	New design and knowledge transfer
D3.5.1	Resistive material: characterisation of different materials	Common resistive material database and procedures
D3.6.1	Mechanics: compression, rigidity, machining precision, etc.	Common approach for the different technologies

Table 12: WG3 - Common Objectives

- a set of objectives identified for each WG
- While asking the confirmation of being part of the collaboration, requiring to express intention on contributing in the listed objectives

Reference	Description	Deliverable Nature
D4.1.1	Garfield++ Modernization: Review Core Code (Multi-Thread, Heterogeneous Arch)	Core Code
D4.1.2	Garfield++ Modernization: Add Community Tools (Automatic Builds etc)	Software Tools
D4.1.3	Garfield++ Modernization: Review & Accelerate neBEM Code	New Release
D4.2.1	Garfield++ Framework Improvement: Recommended Set of Ion Mobilities	New Release
D4.2.2	Garfield++ Framework Improvement: Long-Term Solution for Magboltz	New Release
D4.2.3	Garfield++ Framework Improvement: Displays, Documentation, Examples	New Release

Table 13: WG4 - Objectives 4.1-4.2: Overview

Reference	Description	Deliverable Nature
D5.2.1	SRSe WP1-8	eFEC
D5.2.2	SRSe WP1-8	VMM software and firmware migration
D5.2.3	SRSe - WP1-8	DAQ and reconstruction software
D5.2.4	SRSe	Testing and integration
D5.2.5	Common DAQ/SRS WP1,4	SAMPA implementation
D5.2.6	Common DAQ/SRS - WP4	Timepix3 implementation
D5.2.7	Common DAQ/SRS	RPC front-end implementation(tbd)
D5.2.8	SRS upgrades	2.5 Gbit Ethernet and L0 trigger B
D5.2.9	Portable, Connected μ SRS nodes	readout of distributed, small detectors over long distance

Table 16: WG5 - Objective 5.2: Modernised Readout System

Contributions of DRD1 Institutes

Here tables summarizing Institute Participation in the DRD1 Working Group activities and expression of interest for DRD1 Work Packages

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	WG1	WG2	WG3	WG4	WG5	WG6	WG7	WG8
DRD1 Institutes								
1	ICPD							
2	INP							
3	INP							
4	INP							
5	INP							
6	INP							
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58	INP							
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60	INP							

Figure 5: Institute Participation in the DRD1 Working Group Collaboration activities and expression of interest for DRD1 Work Packages (Part 2).

Resource and infrastructures

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Here tables summarizing
for each WP - main deliverables –
institutions involved/overall FTE
(cumulative informations)

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5.1 Contributions of the DRD1 Institutes

5.2 Synergies with the other DRD Collaborations

5.2.1 DRD2-DRD1 interplay

5.2.2 DRD1 and DRD4 Interplay: Gaseous Photon Detectors Studies

5.2.3 DRD1 and DRD5 Interplay: Synergies in Advanced Materials

5.2.4 DRD1 and DRD6 Interplay: Development of Gaseous Detector-based Calorimeters

5.2.5 Interplay between DRD1 and DRD7

6 Steps towards the formation of the DRD1 Collaboration

6.1 Steps towards the formation of the DRD1 collaboration

Details on the WP are in section 7,
(details on resource in extended WP for
annex Mou -see Piotr's slides)

7 Detailed Description of Research Topics and Work Plan

7.1 Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issues [WG1]

7.1.1 Introduction

7.1.2 Challenges

7.2 Applications [WG2]

7.2.1 Trackers/Hodoscopes (Large Area Muon Systems, Inner Tracking/Vertexing)

7.2.2 Inner and Central Tracking with Particle Identification Capability (Drift Chambers, Straw Chambers and Time Projection Chambers)

7.2.3 Calorimetry

7.2.4 Photo-Detectors (PID)

7.2.5 Timing Detectors (PID and Trigger)

7.2.6 TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)

7.2.7 Beyond HEP

7.3 Gas and Materials [WG3]

7.3.1 Introduction

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7.4 Modelling and Simulations [WG4]

7.4.1 Introduction

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7.4.3 Needs of the Communities

7.5 Electronics for Gaseous Detectors [WG5]

7.5.1 Introduction

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7.5.3 Front-End Challenges for Future Facilities, Experiments and Applications

7.5.4 Plan for Modernized Readout Systems

7.5.5 Topics Beyond the Readout Systems

7.6 Production and Technology Transfer [WG6]

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7.6.2 Quality controls and large volume productions

7.6.3 Collaboration with Industrial Partners

7.6.4 Establishment and support of a forum for sharing experiences, knowledge, and best practices

7.7 Collaboration Laboratories and Facilities [WG7]

7.7.1 Detector Laboratories Network

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7.7.4 Specialised Laboratories

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7.7.6 Detector Test Facilities Databases

7.8 Knowledge Transfer, Training, Career [WG8]

7.8.1 Knowledge exchange and facilitating scientific collaboration

7.8.2 Training and dissemination initiatives

7.8.3 Career promotion

7.8.4 Outreach and education

Detailed Description of Research Topics and Work Plan

#	Task	Performance Goal	DRD1 WG	ECFA DRDT	Comments	Deliv. next 3y	Interested Institutes
T1	IBF reduction	- Gem xIBF < 1-2 - IBF optimization together with energy resolution and discharge stability	WG4, WG7 (7.1-2.5)	1.2	- Hybrid stacks - Cooling GEM - Distortion corrections - Space-charge monitoring - Development of simulation tools - Operation in magnetic fields	- Provide a large-area prototype with a uniform IBF distribution of $G^*IBF \leq 5$ keeping the energy resolution at a tolerable level - Present a structure with stable settings for $G \times IBF$ of 1-2 - Determine the ion blocking power of a GEM-based gate - Provide systematic studies and simulations of IBF performance for the most common structures in high magnetic fields - Introduce an IBF calculator (Garfield-based) for optimization of the HV parameters	INFSP, GSI, U Bonn, INFU/CEA, USTC, KEK-IPNS, IJIS, GANIL, RWTH Aachen, INFN-PD, IPPLM, CERN, PSI, U Bursa, SBU, WIS, U Coimbra, U Aveiro, Wigner, SINP Kolkata
T2	Pixel-TPC development	- Produce 50000-60000 GridPixes to read out a full TPC - Achieve dE/dx counting-resolution < 4%	WG3, WG7 (7.1-2.5)	1.1	- InGrids (grouping of channels) - Low-power FEE - Optimization of pixel size (5-200 μm) or cost reduction	- Provide a large-area pixel-based (InGrid) readout module - Measure IBF for GridPix. Reduction with double-reads - Present dE/dx measurements in beam - Small area prototypes of MPGD/TimePix hybridisation	U Bonn, U Carleton, WIS, CERN
T3	Optimization of the amplification stage and its mechanical structure, and development of low X/X ₀ field cages (FC)	- Uniform response across a readout unit area. - Keep $dE/dx \approx 6\%$ - Point resolution of <100 μm - Minimise static distortions by reducing insensitive areas - Minimise $E \times B$ - Achieve E-field homogeneity at $\sim 10^{-4}$ level	WG1, WG4, WG6, WG7 (7.1-2.5)	1.1 1.2	Minimisation of static distortions - Algorithms for distortion corrections - Field shaping wires - Minimise GEM frame area (use thicker GEMs) - Laser systems Main ampl. stages - Encapsulated resistive-anode MSG - Multiple GEM - GridPix - Hybrids FC: - high-quality strips, suspended strips - module flatness	- Provide a solution for a large-volume TPC with $O(10^6)$ pad-readout, by means of pre-production of several readout modules of comparable quality	INFU/CEA, U Bonn, IHEP CAS, USTC, GANIL, CNRS-IN2P3/CDL, GSI, RWTH Aachen, INFN-RMI, INFN-PD, INFN-BA, IPPLM, PSI, U Bursa, SBU, INFN, WIS, INFN
T4	Low-power FEE	- <5 mW/ch for $>10^6$ pad-TPC - ASIC development in 65 nm CMOS	WG3	1.3	- Continuous vs. pulsed	- Present stable operation of a multi-channel TPC prototype with a low-power ASIC	IHEP/CAS
T5	FEE cooling	- Operate 10^6 channels per read-plate	WG3	1.2	- Two-phase CO ₂ cooling - Micro-channel cooling with 300 μm pipes in carbon fiber tubes - 3D printing: complex structures, performance optimisation, material selection	- Present a prototype of a cooling system for the 10^6 pad TPC option	INFU/CEA, U Lund, INFN-PI, INFN-LE, INFN-PD
T6	Gas mixture	Optimize: - Longevity - Aging - Discharge probability - Diffusion velocity - Ion mobility	WG1, WG3 (3.1D, 3.2A, 3.2B), WG4, WG7 (7.1-3.5)	1.1	- Discharge probability, ageing, gas properties - Optimization of the HV working point - Optimization with the expected resolution (aim for <100 μm) - Cluster ions	- Lower the discharge probability of readout units by 1-2 orders of magnitude down to $\sim 10^{-11}$ per hadron - Avoid secondary discharges in MPGD stacks	CERN, INFSP, GSI, TUM, IHEP CAS, GANIL, USTC, CNRS-IN2P3/CDL, INFU/CEA, CNRS-LSBB, RWTH Aachen, U Bonn, Bose, INFN-RMI, INFN-LE, INFN-PD, INFN-BA, IPPLM, USC/GFHE, U Bursa, SBU, U Warwick, U Aveiro, U Bolnisi-Abram

Currently 8 WPs: for each of them we have description of activities and challenges with detailed tables

Example Work Package 4: Inner and central tracking

Challenges for the TPC at colliders

- Good dE/dx resolution, partly driven by a good gain uniformity;
- very low (gain x Ion Back Flow) to drastically reduce space charge distortions;
- high readout granularity to cope with the particle multiplicity;
- electronics with low power dissipation to meet the increased density of readout channels.
- large area coverage at reduced low cost, relying on lightweight mechanical structures based on composite materials.

Area of application: future electron colliders (ILC, FCC-ee, CEPC). Timeline: 2035-2040, most of the R&D goals should be reached by 2030 to allow for timely construction.

Work Packages description in the proposal

Resource and Participation Tables presented in the proposal as cumulative data (as in Didier's guidelines [here](#))

Currently we have 8 WPs: cumulative information about available resources

WP	Description	Material (2024)	Material (2025)	Material (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Track- ing/Vertexing)	#	#	#	#	#	#
WP2	Inner and Central Track- ing with Particle Identifi- cation Capability (Drift)	#	#	#	#	#	#
WP3	Inner and Central Track- ing with Particle Identifi- cation Capability(Straw)	#	#	#	#	#	#
WP4	Inner and Central Track- ing with Particle Identifi- cation (TPC)	#	#	#	#	#	#
WP5	Calorimetry	#	#	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#	#	#

Proposed table

Table 1: DRD1 Workpackages, cumulative resources (Material[kCHF] and FTE) available in existing funding lines covering the ECFA strategic R&D for the years 2024, 2025, 2026

Work Packages description in the proposal

Cumulative information about additional resource

WP	Description	Material (2024)	Material (2025)	Material (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Track- ing/Vertexing)	#	#	#	#	#	#
WP2	Inner and Central Track- ing with Particle Identifi- cation Capability (Drift)	#	#	#	#	#	#
WP3	Inner and Central Track- ing with Particle Identifi- cation Capability(Straw)	#	#	#	#	#	#
WP4	Inner and Central Track- ing with Particle Identifi- cation (TPC)	#	#	#	#	#	#
WP5	Calorimetry	#	#	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#	#	#

Proposed table

Table 2: DRD1 Workpackages, additional (not existing) funding request to cover the ECFA strategic R&D for the years 2024, 2025, 2026

Work Packages description in the proposal

Cumulative information about resource for material and FTE, projection >2027

WP	Description	Material (2027- 2029)	Material (≥ 2030)	FTE (2027- 2029)	FTE (≥ 2030)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Tracking/Vertexing)	#	#	#	#
WP2	Inner and Central Tracking with Particle Identification Capability (Drift)	#	#	#	#
WP3	Inner and Central Tracking with Particle Identification Capability(Straw)	#	#	#	#
WP4	Inner and Central Tracking with Particle Identification (TPC)	#	#	#	#
WP5	Calorimetry	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#

Proposed table

Table 3: DRD1 Workpackages, resources projections for the years 2027-2029, ≥ 2030 .

Here the table summarizing list of the available facilities in the DRD1 Institutes

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DRD1 Institutes	Detector Characterization Laboratory	Manufacturing and Production Workshop	Assembly Facilities	Clean Rooms	Gas system design and production	Mechanical Workshop	Electronics Workshop	Analysis Laboratory	Metrology Laboratory	Radioactive Sources (active, passive)	Irradiation Facilities	Test Beam	Other
AMJ													
VUB and UGent													
IRUP													
U Safta													
HEP CAS													
USTC													
CTU													
HP													
GAPL													
CNRS-INP3/UCLab													
IFD													
IRFU/CEA													
CNRS-LM6													
ISI													
U Wuerzburg													
MPP													
U Heidelberg													
U Bonn													
INSAP Bonn													
NSRF Demokritos													
NTU Athens													
Bonn													
NSDF Shubanev													
MSL													
WRI													
GSI													
INFN-LNF													
INFN-BNL													
INFN-SA													
INFN-FI													
INFN-AN													
INFN-BO													
INFN-FS													
INFN-PV													
INFN-BN													
U Kobe													
AGH-Krakow													
AstroCaNT													
IPPIM													
RI-Krakow													
UP-Cologne													
INFN-PA													
U Zaragoza													
USC/BBP													
U Chiba													
ISI													
CERN													
PSI													
U Gifu-Akita													
U Bonn													
U Liverpool													
U Manchester													
MSU													
ITP													
IRU													
Rub													
UH Mainz													
UW-Madison													

Figure 6: List of the available facilities in the DRD1 Institutes. The shown information have been collected during the first DRD1 survey and needs to be updated to include all the interested institutes

Synergies with other DRDs

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DRD1 proposal finalization timeline

To be agreed with DRDC chair

- **March- 5 May:** **draft document** preparation including a preliminary definition of Work Package
- **15 May:** Start the community consultation. 1st Draft shared with Institute Contacts.
- **15 May - 1 June:** Proposal Team works on the draft document within working groups, implementing the feedback from the community and preparation of the preliminary version of the Executive Summary with WP tables.
- **1 June:** End of the community feedback about the first draft
- **16 June:** Approval of the document for the community-wide discussion and release to the 2nd draft whole community.
- **22-23 June:** DRD1 Community workshop - wide discussions during the community workshop
- **June- July:** - Definition of the required resources for the outlined programme need (split into personnel effort (FTEs) and material plus services (non-FTE) costs. – institute's inputs
- **End-July:** Submission of the proposal without resource information (to be agreed with DRDC chair)
- **Sept/October:** Resource table included, although with no guarantee at this stage that the figures appearing can be committed (date to be agreed with DRDC chair)