A Molecular Breeding Platform

Portal, Information System, Toolbox
and Services

Graham McLaren

17/02/09

Generation
Cultivating Plant Diversity for the Resource-Poor

Rationale

- revolutions in molecular biology and information technology offer opportunities for enhancing plant breeding

- successfully deployed in the private sector but are not generally used in the public sector and hardly ever in developing countries

- It is time to provide the appropriate support tools, services and infrastructure to offer breeding programmes in developing countries access to modern marker breeding technologies

Generation

Project Objectives

- Develop and deploy a functional and sustainable molecular breeding platform
    - providing access to molecular breeding services,
    - an information system and a
    - toolbox of analysis and decision support applications
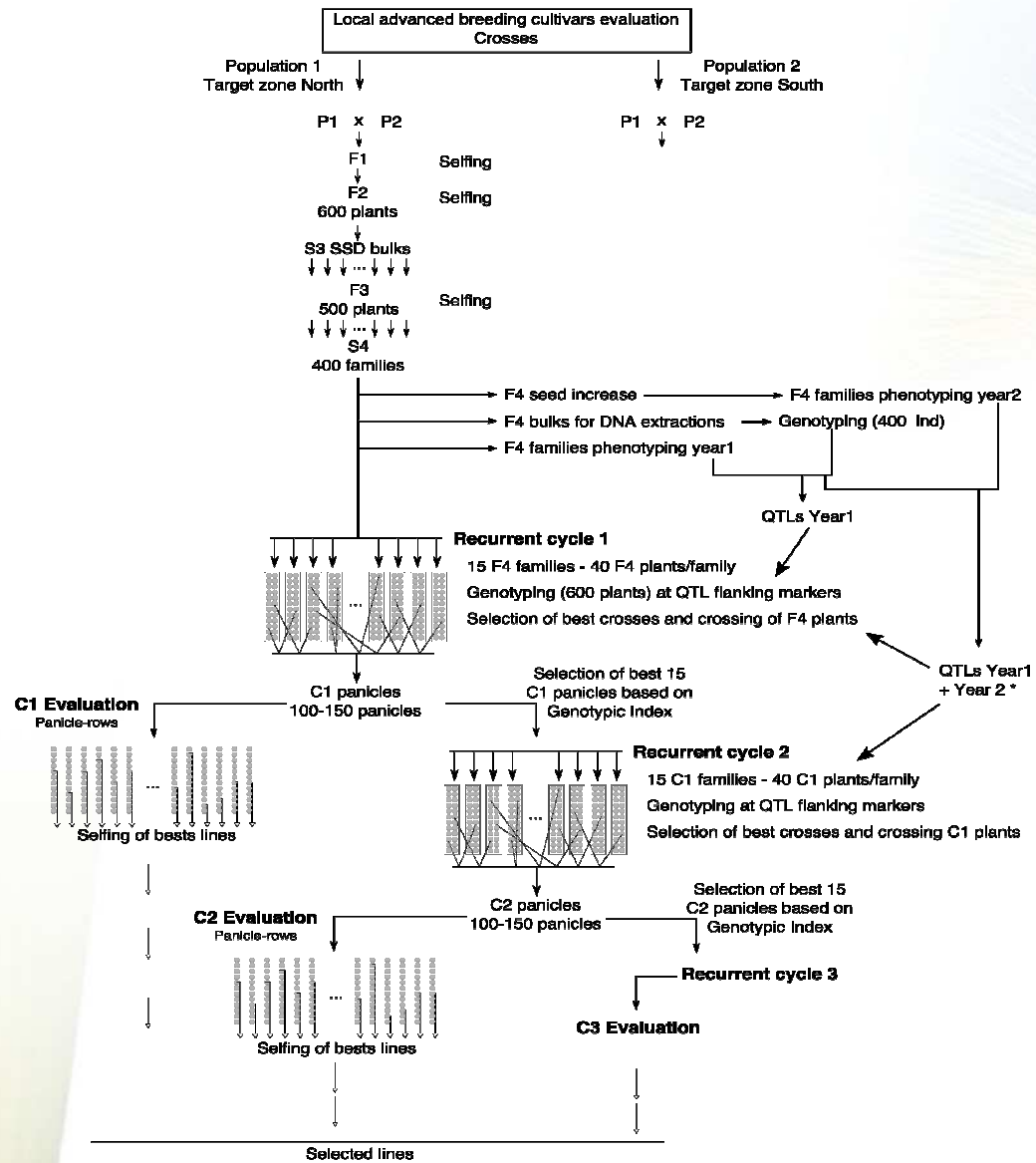
Generation

Use case projects

- **Beans:** Improving tropical legume productivity for marginal environments in sub-Saharan Africa (Tropical Legumes I, Gates Foundation–GCP project, Mathew Blair, CIAT)
- **Chickpeas:** Improving tropical legume productivity for marginal environments in sub-Saharan Africa (Tropical Legumes I, Gates Foundation–GCP project, Pooran Gaur, ICRISAT)
- **Cowpeas:** Improving tropical legume productivity for marginal environments in sub-Saharan Africa (Tropical Legumes I, Gates Foundation–GCP project, Jeff Ehlers, University of California–Riverside)
- **Maize:** Drought-tolerant maize for Africa, (Gates Foundation project, Gary Atlin, CIMMYT)
- **Maize:** Drought-tolerant maize for Asia (GCP project, Pervez Zaidi, CIMMYT)
- **Rice:** Stress-tolerant rice for poor farmers in Africa and South Asia (Gates Foundation project, David Mackill, IRRI)
- **Rice:** Drought-tolerant rice for China (Gates Foundation project, Zhikang Li, CAAS–IRRI)
- **Sorghum:** Yield improvement of sorghum in Africa through marker-assisted recurrent selection (GCP project, Jean-François Rami, CIRAD)
- **Wheat:** Molecular marker technologies for faster wheat breeding in India (ACIAR project, Richard Trethowan, Sydney University)
- **Wheat:** Durable rust resistance in wheat (Gates Foundation project, Mike Pumphrey, USDA/Cornell Univeristy)

Generation

2008 — 2009 — 2010 — 2011 — 2012

Activity	Jun 2008 – Dec 2012
Sowing of parents	
Field phenotyping of parents	
Crosses	
F1 harvest	
Sowing of F1	
F2 Harvest	
Sowing of F2	
F3 Harvest	
Sowing of F3	
F4 Harvest	
DNA production of F3 plants (F4 bulks)	
Genotyping of F3 plants	
Multilocal phenotyping of F4 families	
Recurrent Cycle 1 (C1)	
C1 Genotyping	
Recurrent Cycle 2 (C2)	
C2 Genotyping	
Observation of C1	
Recurrent Cycle 3 (C3)	
C3 Genotyping	
Observation of C1,C2,C3	

The sorghum use case: 'Improve sorghum productivity in sub-Saharan environments of Mali through integrated MARS'

Information system

Tool box

Pedigree information management	
Field Data management	
Laboratory information management	
Analysis and decision support tools	

Services

Breeding services

GRSS	
Marker service Laboratories	
Trait service laboratories	

Support Services

Information management	
Data curation	
Design and analysis	
IP and policy	
Genotyping support service	
Training activities	

Local advanced breeding cultivars evaluation
Crosses

Population 1
Target zone North

Population 2
Target zone South

P1 x P2

P1 x P2

F1   Selfing

F2   Selfing
600 plants

S3 SSD bulks

F3   Selfing
500 plants

S4
400 families

F4 seed increase ──────→ F4 families phenotyping year2

F4 bulks for DNA extractions ──→ Genotyping (400 Ind)

F4 families phenotyping year1

QTLs Year1

Recurrent cycle 1
15 F4 families - 40 F4 plants/family
Genotyping (600 plants) at QTL flanking markers
Selection of best crosses and crossing of F4 plants

QTLs Year1
+ Year 2 *

C1 Evaluation
Panicle-rows

C1 panicles
100-150 panicles

Selection of best 15
C1 panicles based on
Genotypic Index

Recurrent cycle 2
15 C1 families - 40 C1 plants/family
Genotyping at QTL flanking markers
Selection of best crosses and crossing C1 plants

Selfing of bests lines

C2 Evaluation
Panicle-rows

C2 panicles
100-150 panicles

Selection of best 15
C2 panicles based on
Genotypic Index

Recurrent cycle 3

C3 Evaluation

Selfing of bests lines

Selected lines

(*) : the QTL detection will be repeated for a second year.
The consolidated QTL results including two years of phenotyping
will be used either to refine the choice of target regions in C2
recurrent cycle or start another C1 recurrent cycle from F4 plants
or a combination of F4 and C1 plants

Generation

Major outputs

- *A Molecular Breeding Portal*
  - A web-based interface, providing access to the platform
  - A help desk providing assistance to portal users
- *An Information System*
  - A modular information system
  - A middleware layer of software which integrates data
  - Accumulation of breeding data
- Services
  - Breeding Services
  - Support Services

2. Information System

Objective 2.1: Make existing tools for data management and breeding logistics available to molecular breeding projects through the MBP

→ **Logistics and Data management**
- Pedigree Information Management
- Field Data Management
- Laboratory Information Management

Objective 2.2: Develop a suite of analysis, prediction and simulation tools for MAB

→ **Analysis and Decision Support**
- Statistical and genetic analysis
- Cross prediction and selection
- Modeling and simulation tools
- Visualisation and decision support

Objective 2.3: Develop an information network, decision support tools and a workflow management system for molecular breeding

→ **Information Network and Workflow System**
- Information network infrastructure
- Public crop information
- Configurable workflow system

Generation

Objective 3.1: Provide access to critical molecular breeding services

Objective 3.2: Provide assistance with a range of molecular breeding support services

3. Services

Breeding Services
- Genetic Resource Support Service
- Marker service laboratories
- Trait service laboratories

Support Services
- Business Plan development
- Information management & data curation
- Design and analysis
- Phenotyping sites & screening protocols
- Genotyping Support Service
- IP and policy

Generation

Project Implementation

- build on infrastructure and expertise that already exists

- boost individual initiatives and to link people with complementary expertise

- work with partners with common interests in building and using a public Molecular Breeding Platform

Generation

Existing GCP Technology and Services

- web technology from the GCP Informatics Platform to create the Portal,

- domain model and semantic standards for data integration,

- middleware, datasource and application programming interfaces, and web services technology,

- the Molecular Marker Information and Toolbox,

- GCP Phenotyping protocol and analysis projects,

- Genetic Resource Support Service (GRSS),

- Genotyping Support Service (GSS),

- SP4 Analysis Helpdesk, and

- IP and policy Helpdesk.

Generation

Platform Management

- Platform Manager to:
  - manage the Portal and Help Desk,
  - manage the Platform Services
  - coordinate regional activities through site visits
  - coordinate human resources development
- A user committee will be constituted to
  - advise on the design of the platform elements,
  - to test different elements of the platform and
  - to provide feedback on the evolution of the portal.
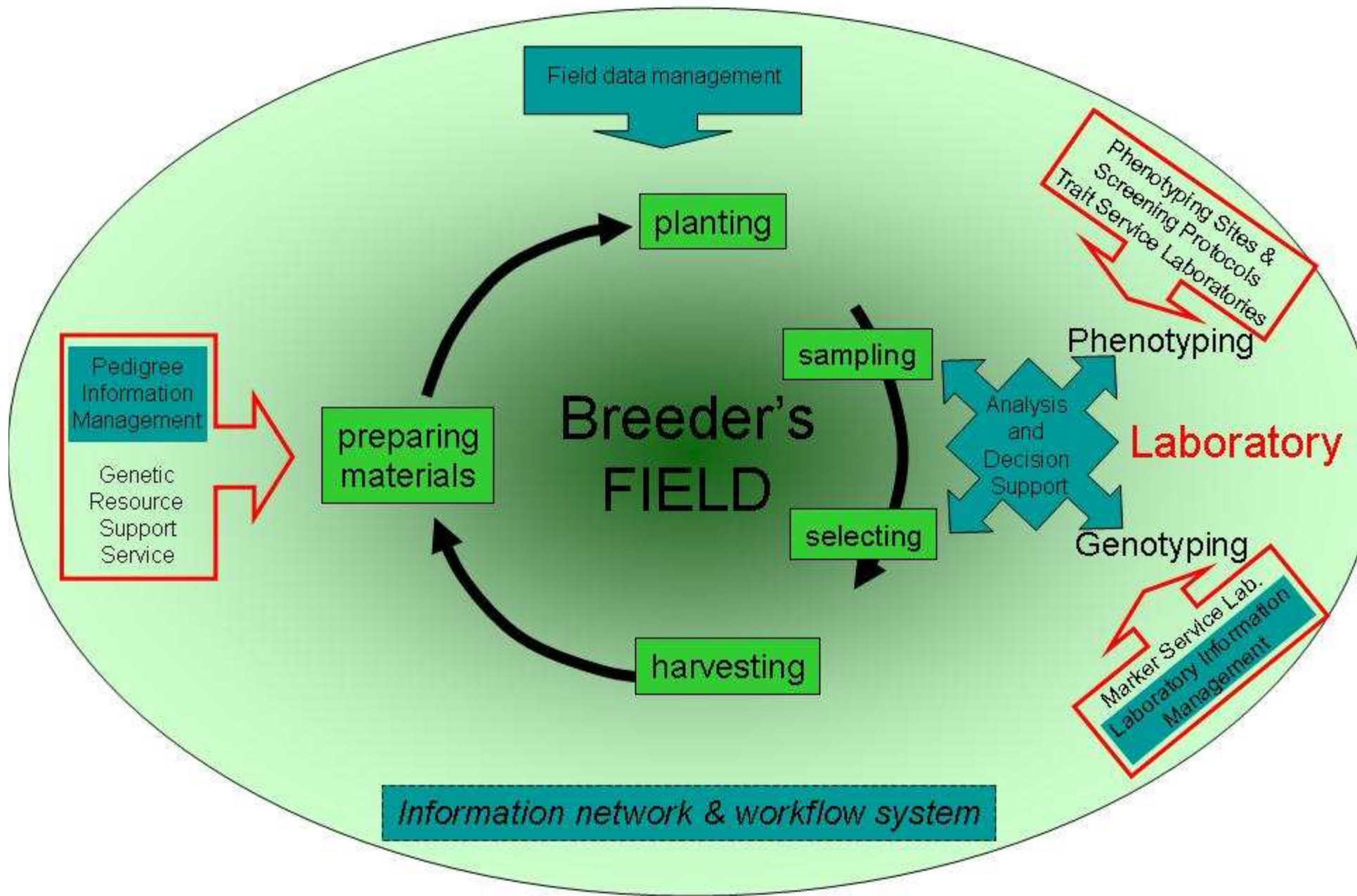
Generation

Objective 2.1 Make existing tools for data management and breeding logistics available to molecular breeding projects through the MBP.

- Identify, deploy and support tools facilitating management of germplasm lists, pedigrees, intellectual property and other passport data

- Identify, deploy and support tools for management of phenotypic characterisation and evaluation

- Identify, deploy and support tools for management of genotypic characterization

Objective 2.2 Develop a suite of analysis, prediction and simulation tools for MAB

- Develop and deploy statistical and genetic analysis for molecular breeding

- Develop and deploy cross prediction and selection methodology for molecular breeding

- Develop and deploy simulation tools for complex G-E systems

Generation

Objective 2.3 Develop an information network, decision support applications and a workflow management system for molecular breeding
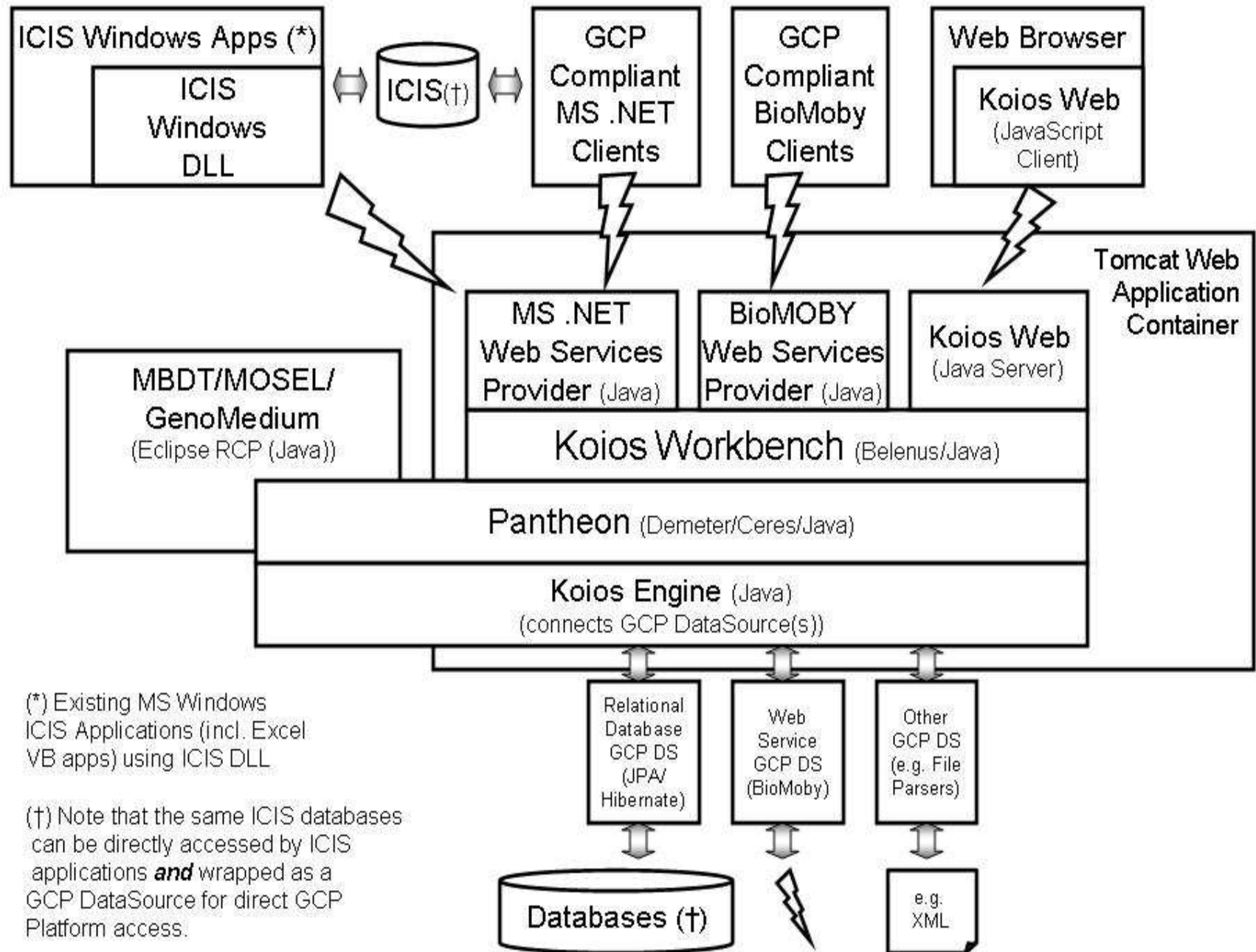
- Establish middleware infrastructure for networking databases and applications

- Develop and integrate visualisation and decision support applications

- Implement a configurable workflow system for molecular breeding

Generation

GCP Platform Architecture 2008 – Updated Details
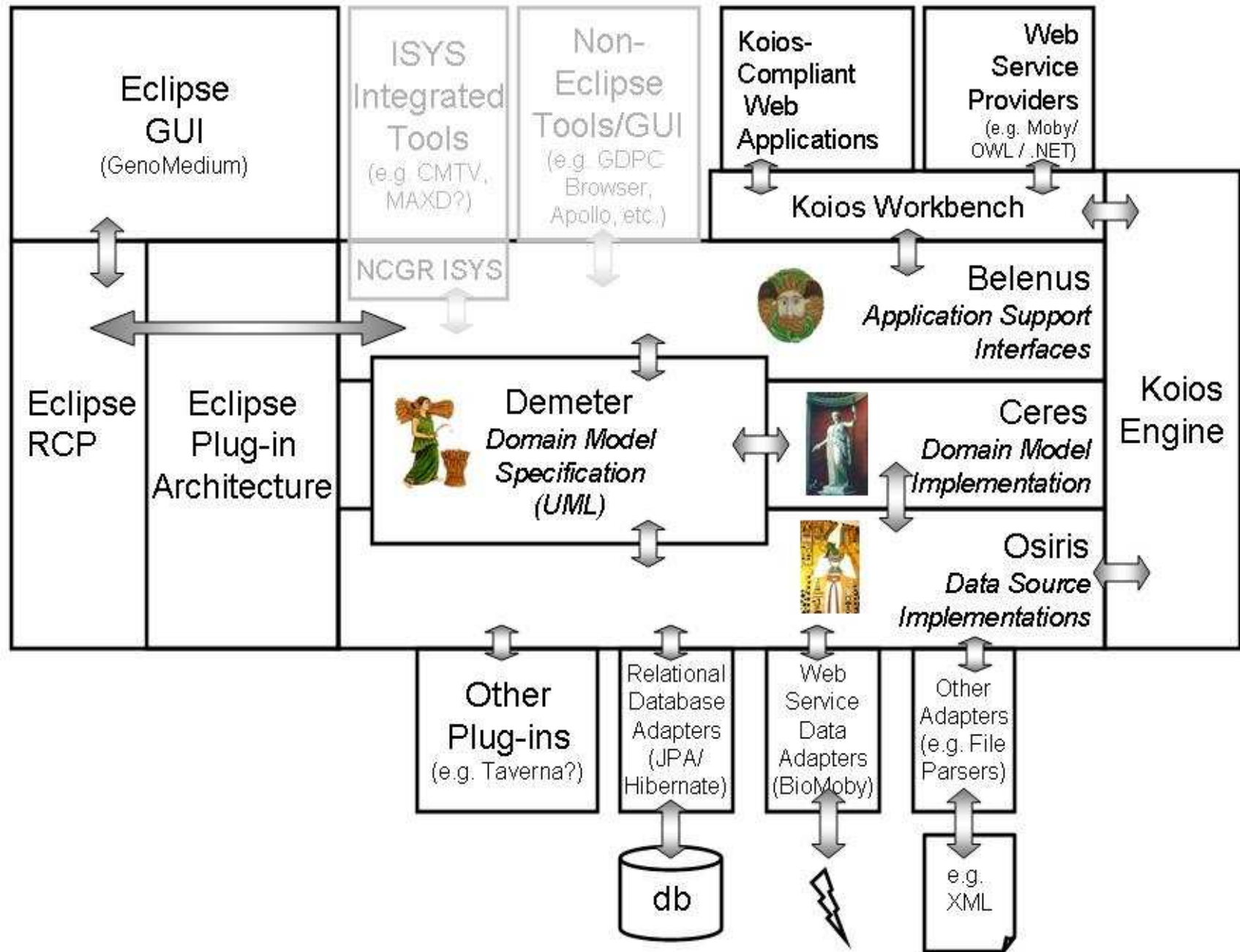
GCP-Compliant Molecular Breeding Platform Framework

(*) Existing MS Windows ICIS Applications (incl. Excel VB apps) using ICIS DLL

(†) Note that the same ICIS databases can be directly accessed by ICIS applications **and** wrapped as a GCP DataSource for direct GCP Platform access.

Objective 3.1 Provide access to critical molecular breeding services.

- Genetic Resource Support Service

- Marker Services

- Trait and Metabolite Services

Objective 3.2 Provide assistance with a range of molecular breeding support services.

- Business Plan Development
- Information Management
- Data Curation
- Design and Analysis
- Phenotyping Sites and Screening Protocols
- Genotyping Support Services
- IP Helpdesk

Generation

Potential Risks

- The platform is technology push and not demand-driven
- The platform is not sustainable
- The platform is not adopted/used by breeders
- Access to the data generated through the platform is limited

No	Activity	Leader	Institute
Component 1 – Molecular Breeding Portal and Helpdesk			
Objective 1.1: Establish and Manage the Molecular Breeding Platform			
	1.1.1 Establishment of the molecular breeding platform	Graham McLaren	GCP
	1.1.2 Develop and deploy the molecular breeding portal	Platform Manager	GCP
	1.1.3 Establish molecular breeding platform helpdesk and coordinate training and communication activities	Platform Manager	GCP

Component 2 – Information System

Objective 2.1 Make existing tools for data management and breeding logistics available to molecular breeding projects through the MBP

	2.1.1 Identify, deploy and support tools facilitating management of germplasm lists, pedigrees, intellectual property and other passport data)	Fran Clarke Shawn Yates	AAFC
	2.1.2 Identify, deploy and support tools for management of phenotypic characterization and evaluation	Arllet Portugal	CIMMYT
	2.1.3 Identify, deploy and support tools for management of genotypic characterisation	Jayashree B	ICRISAT

Objective 2.2 Develop a suite of analysis, prediction and simulation tools for MAB			
	2.2.1 Develop and deploy statistical and genetic analysis for molecular breeding	Fred van Eeuwijk	WUR
	2.2.2 Develop and deploy cross prediction and selection methodology for molecular breeding	Alain Charcosset	INRA
	2.2.3 Develop and deploy simulation tools for complex G-E systems	Mark Dieters	UoQ

Generation

Objective 2.3 Develop an information network, decision support tools and a workflow management system and for molecular breeding			
	2.3.1 Establish middleware infrastructure for networking databases and applications	M Senger	IRRI
	2.3.2 Integration and development of visualisation and decision support applications	Guy Davenport	CIMMYT
	2.3.3 Implement a configurable workflow system for molecular breeding	Richard Bruskiewich	IRRI

Generation

Component 3 – Services			
Objective 3.1 Provide access to critical molecular breeding services			
	3.1.1 Genetic Resource Support Service	JC Glaszmann	GCP
	3.1.2. Marker Services	H Gómez-Paniagua	GCP
	3.1.3 Trait and metabolite services	SP3 Leader	GCP

Objective 3.2 Provide assistance with a range of molecular breeding support services			
	3.2.1 Business Plan Development	Platform Manager	GCP
	3.2.2 Information Management	T Metz	IRRI
	3.2.3 Data Curation	T Metz	IRRI
	3.2.4 Design and Analysis	F van Eeuwijk	WUR
	3.2.5 Phenotyping sites and screening protocols	SP3 Leader	GCP
	3.2.6 Genotyping Support Service	H Gómez-Paniagua	GCP
	3.2.7 IP Helpdesk	H Gómez-Paniagua	GCP