Proof-of-concept versus production: technological readiness levels

Proof of Concept (PoC)

- PoC is a realization of a certain method or idea in order to demonstrate its feasibility, or a demonstration in principle with the aim of verifying that some concept or theory has practical potential
- PoC university centers to fill the funding gap for seed-stage investing and accelerate the commercialization of university innovations.
- In software development, PoC characterises several distinct processes with different objectives and participant roles:
  - vendor business roles may utilise a PoC to establish whether a system satisfies some aspect of the purpose it was designed for.
  - Once a vendor is satisfied, a prototype is developed which is then used to seek funding or to demonstrate to prospective customers

PoC vs. PoT / Pilot project

- By contrast, a proof of technology (PoT) aims to determine the solution to some technical problem (such as how two systems might integrate) or to demonstrate that a given configuration can achieve a certain throughput.
  - No business users need be involved in a proof of technology.
- A pilot project refers to an initial roll-out of a system into production, targeting a limited scope of the intended final solution.
  - The scope may be limited by the no. users who can access the system, the business processes affected, the business partners involved, or other restrictions.
  - The purpose of a pilot project is to test, often in a production environment.

PoC | Pilot | Production

PoC

- Definition of success criteria
- Engineering the proposed solution
- Evaluation of solution against success criteria
- Decision to move forward

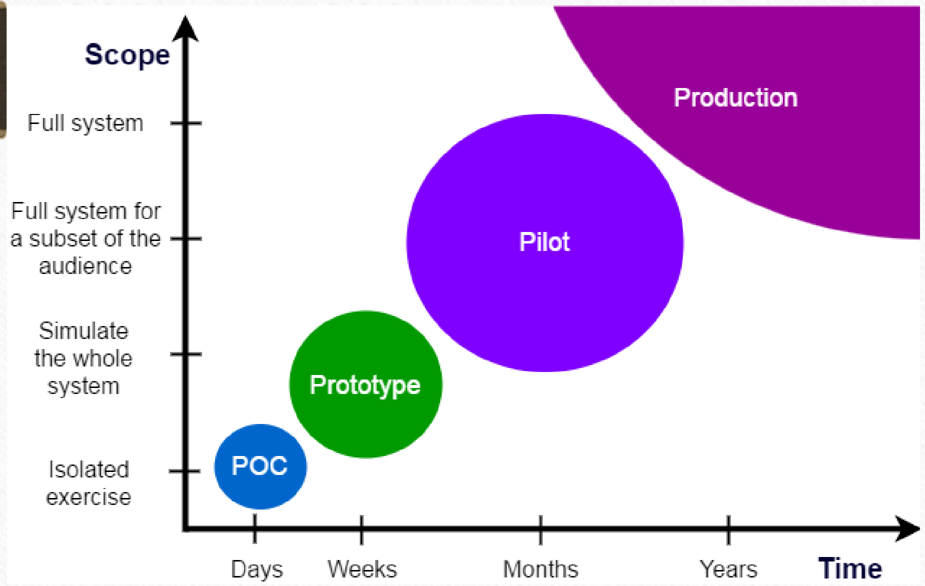
Pilot

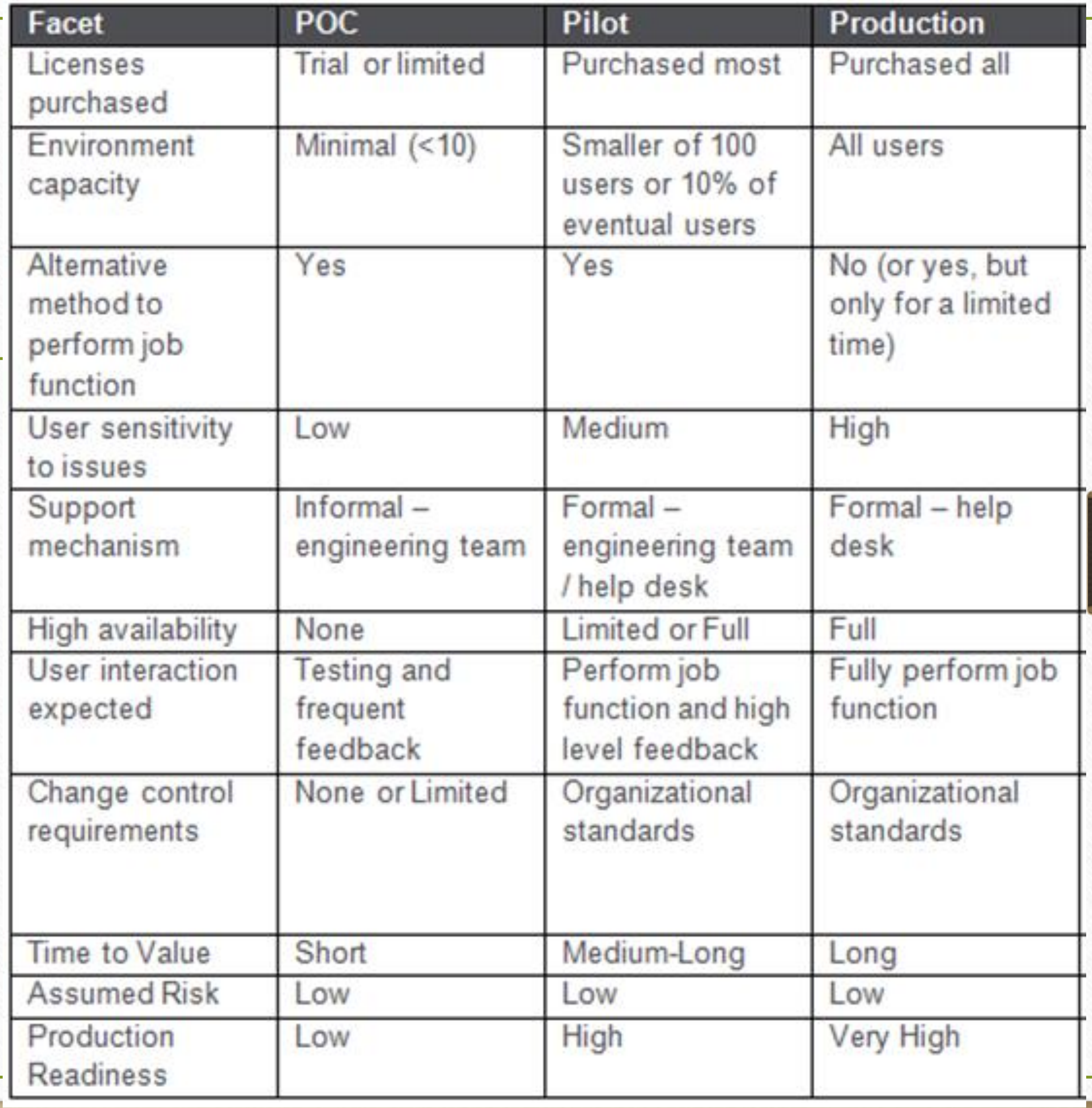
- Detailed architectural design
- Environment build and configuration
- Infrastructure testing to validate failover
- User testing and iterative feedback
- Documentation or training for pilor users

Production

- Training of end-users
- Schedule for transition to the new systems
- Placement of the environment into operation and support organization/process

Citrix matrix: PoC vs. Pilot vs. Production





Facet	POC	Pilot	Production
Licenses purchased	Trial or limited	Purchased most	Purchased all
Environment capacity	Minimal (<10)	Smaller of 100 users or 10% of eventual users	All users
Alternative method to perform job function	Yes	Yes	No (or yes, but only for a limited time)
User sensitivity to issues	Low	Medium	High
Support mechanism	Informal – engineering team	Formal – engineering team / help desk	Formal – help desk
High availability	None	Limited or Full	Full
User interaction expected	Testing and frequent feedback	Perform job function and high level feedback	Fully perform job function
Change control requirements	None or Limited	Organizational standards	Organizational standards
Time to Value	Short	Medium-Long	Long
Assumed Risk	Low	Low	Low
Production Readiness	Low	High	Very High

Technology readiness level (TRL)

- is a method for estimating the maturity of technologies
- developed at NASA during the 1970s.
- the use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology.
- a technology's TRL is determined during a Technology Readiness Assessment (TRA) that examines program concepts, technology requirements, and demonstrated technology capabilities.
- TRLs are based on a scale from 1 to 9 with 9 being the most mature technology

European TRL system

TRL 1 – Basic principles observed

TRL 2 – Technology concept formulated

TRL 3 – Experimental proof of concept

TRL 4 – Technology validated in lab

TRL 5 – Technology validated in relevant environment

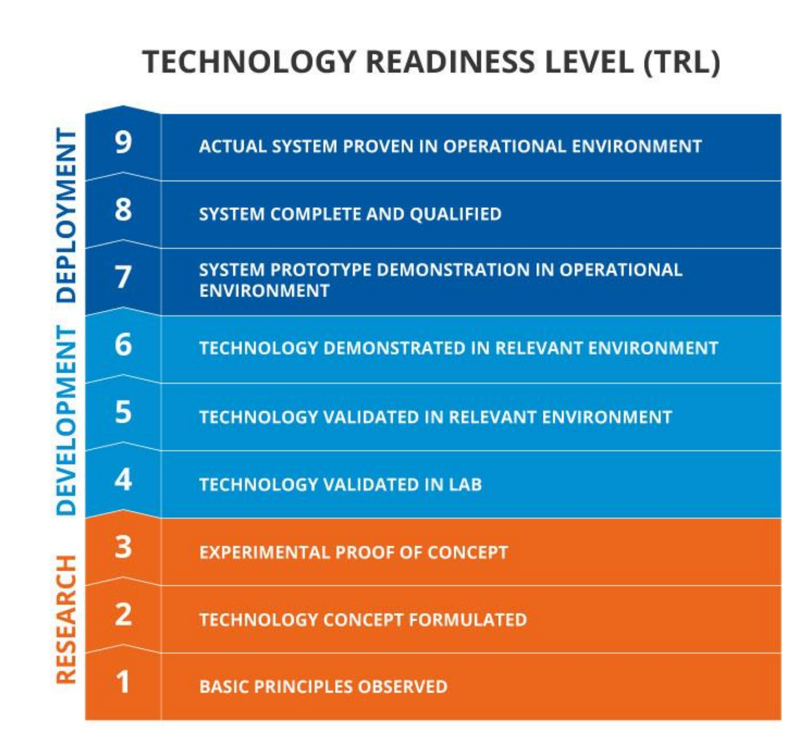
TRL 6 – Technology demonstrated in relevant environment

TRL 7 – System prototype demonstration in operational environment

TRL 8 – System complete and qualified

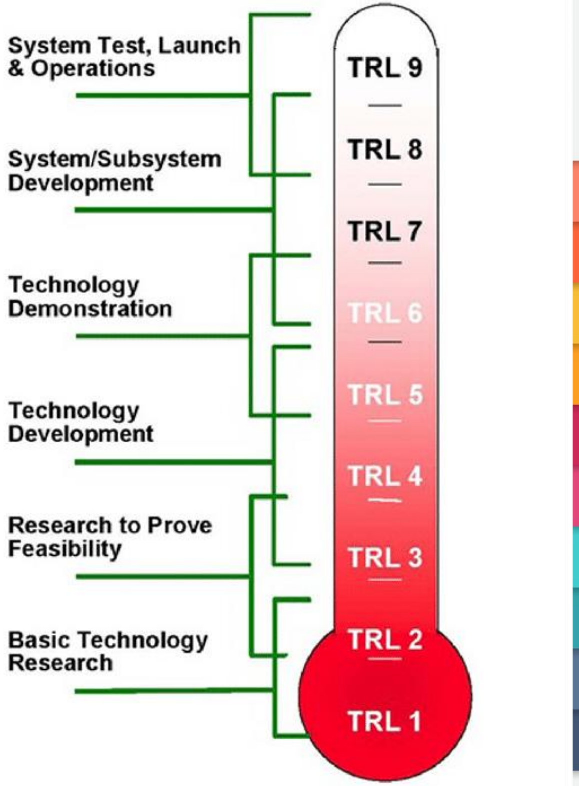
TRL 9 – Actual system proven in operational environment

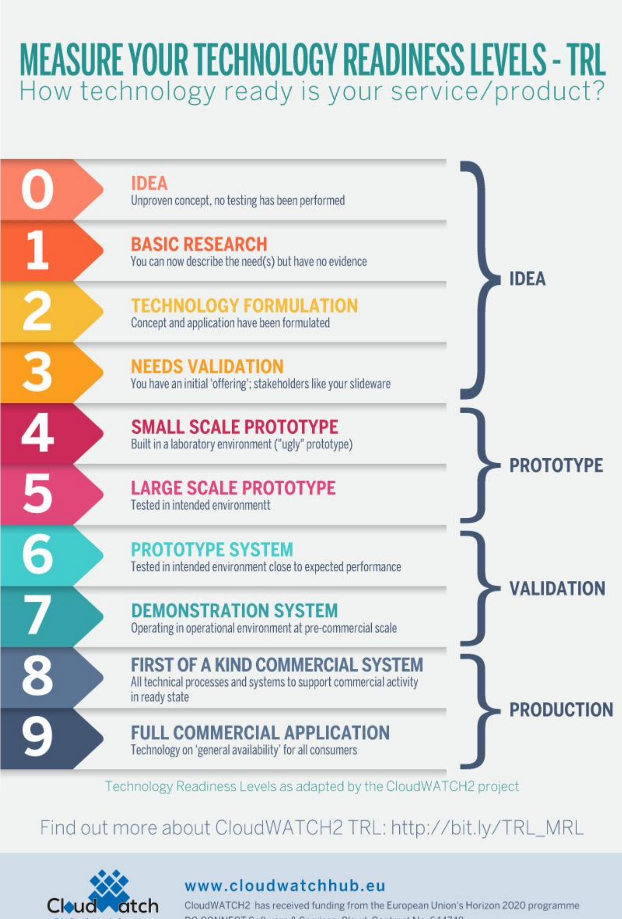
What is measuring?



TECHNOLOGY READINESS LEVEL (TRL)

DEPLOYMENT	9	ACTUAL SYSTEM PROVEN IN OPERATIONAL ENVIRONMENT
	8	SYSTEM COMPLETE AND QUALIFIED
	7	SYSTEM PROTOTYPE DEMONSTRATION IN OPERATIONAL ENVIRONMENT
DEVELOPMENT	6	TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT
	5	TECHNOLOGY VALIDATED IN RELEVANT ENVIRONMENT
	4	TECHNOLOGY VALIDATED IN LAB
RESEARCH	3	EXPERIMENTAL PROOF OF CONCEPT
	2	TECHNOLOGY CONCEPT FORMULATED
	1	BASIC PRINCIPLES OBSERVED


System Test, Launch & Operations
System/Subsystem Development
Technology Demonstration
Technology Development
Research to Prove Feasibility
Basic Technology Research
TRL 9
TRL 8
TRL 7
TRL 6
TRL 5
TRL 4
TRL 3
TRL 2
TRL 1



MEASURE YOUR TECHNOLOGY READINESS LEVELS - TRL

How technology ready is your service/product?

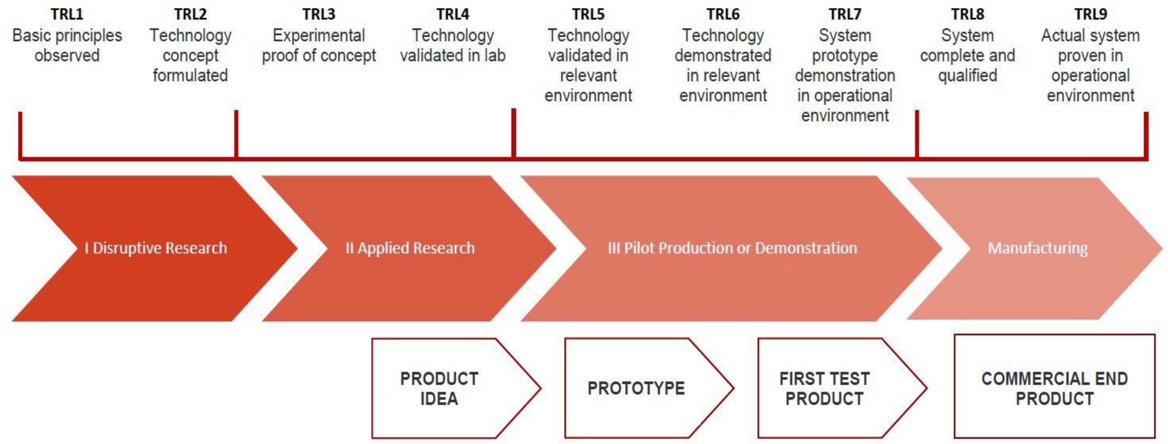
0	**IDEA** Unproven concept, no testing has been performed	IDEA
1	**BASIC RESEARCH** You can now describe the need(s) but have no evidence	
2	**TECHNOLOGY FORMULATION** Concept and application have been formulated	
3	**NEEDS VALIDATION** You have an initial 'offering'; stakeholders like your slideware	
4	**SMALL SCALE PROTOTYPE** Built in a laboratory environment ("ugly" prototype)	PROTOTYPE
5	**LARGE SCALE PROTOTYPE** Tested in intended environmentt	
6	**PROTOTYPE SYSTEM** Tested in intended environment close to expected performance	VALIDATION
7	**DEMONSTRATION SYSTEM** Operating in operational environment at pre-commercial scale	
8	**FIRST OF A KIND COMMERCIAL SYSTEM** All technical processes and systems to support commercial activity in ready state	PRODUCTION
9	**FULL COMMERCIAL APPLICATION** Technology on 'general availability' for all consumers	

Technology Readiness Levels as adapted by the CloudWATCH2 project

Find out more about CloudWATCH2 TRL: http://bit.ly/TRL_MRL

CloudWatch
www.cloudwatchhub.eu
CloudWATCH2 has received funding from the European Union's Horizon 2020 programme

What is measuring?



TRL1 Basic principles observed

TRL2 Technology concept formulated

TRL3 Experimental proof of concept

TRL4 Technology validated in lab

TRL5 Technology validated in relevant environment

TRL6 Technology demonstrated in relevant environment

TRL7 System prototype demonstration in operational environment

TRL8 System complete and qualified

TRL9 Actual system proven in operational environment

I Disruptive Research

II Applied Research

III Pilot Production or Demonstration

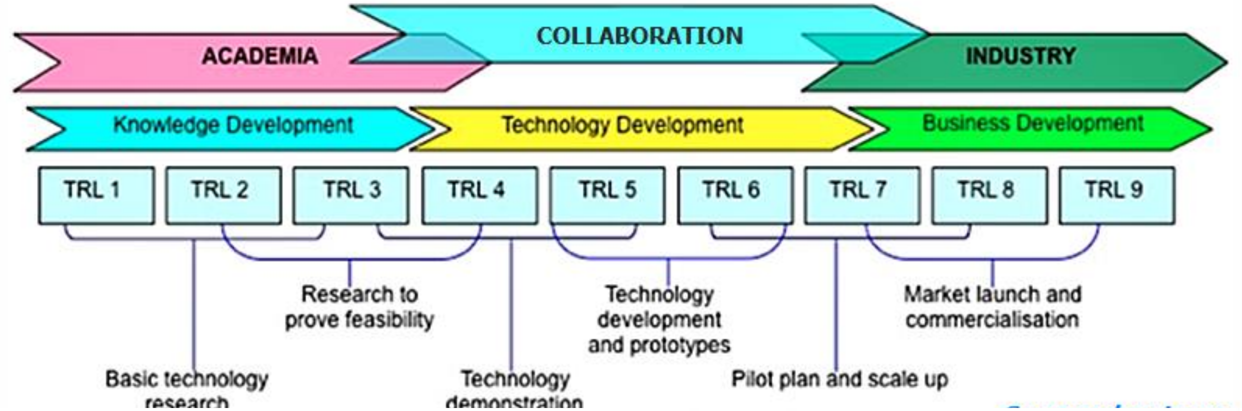
Manufacturing

PRODUCT IDEA

PROTOTYPE

FIRST TEST PRODUCT

COMMERCIAL END PRODUCT



ACADEMIA

COLLABORATION

INDUSTRY

Knowledge Development

Technology Development

Business Development

TRL 1 TRL 2 TRL 3 TRL 4 TRL 5 TRL 6 TRL 7 TRL 8 TRL 9

Research to prove feasibility

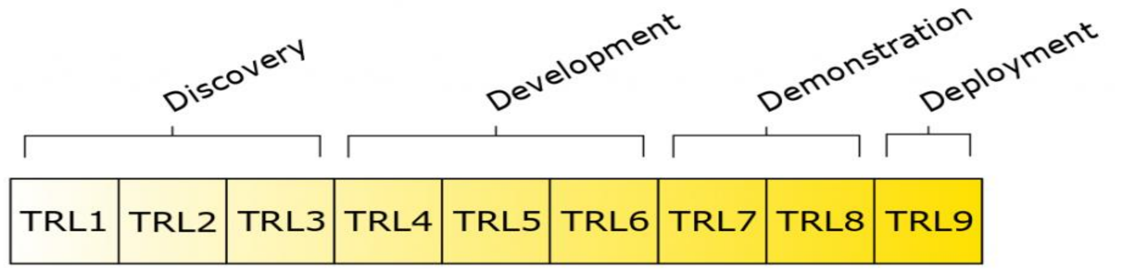
Technology development and prototypes

Market launch and commercialisation

Basic technology research

Technology demonstration

Pilot plan and scale up



Discovery

Development

Demonstration

Deployment

TRL1 TRL2 TRL3 TRL4 TRL5 TRL6 TRL7 TRL8 TRL9

TRL 1-3 - comments

TRL	Description	Example
1	Basic principles observed	Scientific observations made and reported. Examples could include paper-based studies of a technology's basic properties.
2	Technology concept formulated	Envisioned applications are speculative at this stage. Examples are often limited to analytical studies.
3	Experimental proof of concept	Effective research and development initiated. Examples include studies and laboratory measurements to validate analytical predictions.

TRL 4-6 - comments

4	Technology validated in lab	Technology validated through designed investigation. Examples might include analysis of the technology parameter operating range. The results provide evidence that envisioned application performance requirements might be attainable.
5	Technology validated in relevant environment	Reliability of technology significantly increases. Examples could involve validation of a semi-integrated system/model of technological and supporting elements in a simulated environment.
6	Technology demonstrated in relevant environment	Prototype system verified. Examples might include a prototype system/model being produced and demonstrated in a simulated environment.

TRL 7-9 - comments

7	System prototype demonstration in operational environment	A major step increase in technological maturity. Examples could include a prototype model/system being verified in an operational environment.
8	System complete and qualified	System/model produced and qualified. An example might include the knowledge generated from TRL 7 being used to manufacture an actual system/model, which is subsequently qualified in an operational environment. In most cases, this TRL represents the end of development.
9	Actual system proven in operational environment	System/model proven and ready for full commercial deployment. An example includes the actual system/model being successfully deployed for multiple missions by end users.

Example for the TRLs of a software class

- **Principle (TRL 1):** The basic requirements of the principle are described and the class stub created.
- **Concept (TRL 2):** The basic design elements of the class are described and the variables enumerated in the class.
- **Proof (TRL 3):** The methodology to be used has been proven on paper or numerically in other environments.
- **Standalone (TRL 4):** The class has been implemented and passed standalone methodological and functional validation tests.
- **Integrated (TRL 5):** The class has been tested in conjunction with other classes and passed integrated methodological and functional validation tests
- **Demonstrated (TRL 6):** The class has been shown to produce correct results in simple exemplary situations.
- **Prototype (TRL 7):** The class has been shown to produce correct results in complex exemplary situations.
- **Qualified (TRL 8):** The class has been shown to produce correct results in realistic situations.
- **Proven (TRL 9):** The class has been used successfully in production-grade analysis work.