



(51) International Patent Classification:

G05B 13/04 (2006.01) A01G 25/16 (2006.01)
G06Q 50/02 (2012.01) G05B 19/46 (2006.01)

(21) International Application Number:

PCT/AU2018/050990

(22) International Filing Date:

12 September 2018 (12.09.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

2017903691 12 September 2017 (12.09.2017) AU

(71) Applicant: JAIN AGRICULTURE SERVICES AUSTRALIA PTY LTD [AU/AU]; 77 Argyle Street, Fitzroy, Victoria 3065 (AU).

(72) Inventor: PRYOR, James Matthew; C/- 77 Argyle Street, Fitzroy, Victoria 3065 (AU).

(74) Agent: DAVIES COLLISON CAVE PTY LTD; 1 Nicholson Street, Melbourne, Victoria 3000 (AU).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH,

(54) Title: INTEGRATED INTELLIGENT IRRIGATION SYSTEM DESIGN, IMPLEMENTATION AND MONITORING

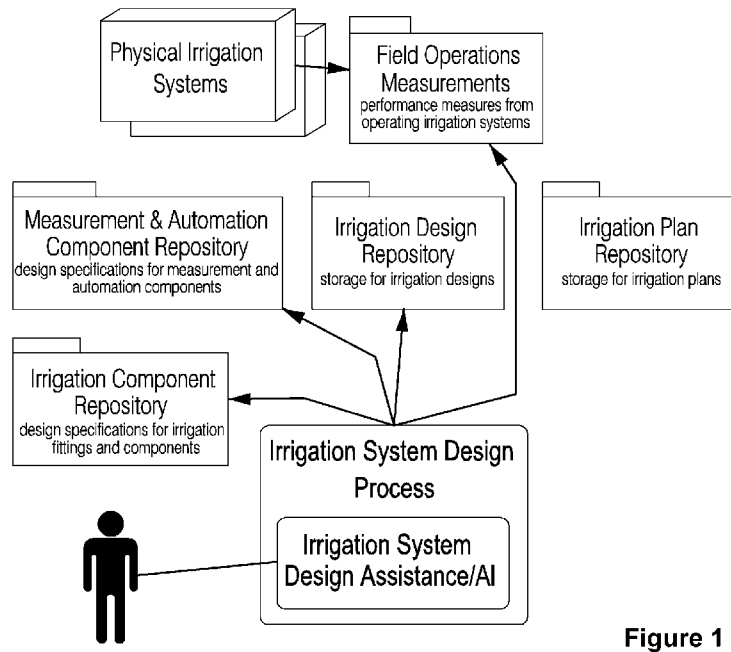


Figure 1

(57) Abstract: A method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time comprising: • receiving data associated with a proposed irrigation design; • analysing the proposed design comprising one or more proposed measurements and automation requirements; • retrieving one or more pre-established estimation rules from a data store and mapping them with the proposed design; • estimating additional measurement and automation requirements based on one or more such estimation rules; • adjusting one or more estimation rules based on real data associated with operation of a previous/current irrigation system; • estimating one or more of acquisition, installation and operating costs based on one or more of: hardware costs; radio network propagation characteristics (optionally of terrain, crop, etc); other factors that have historically contributed to ownership cost; • displaying to a user one or more of such estimated costs; • calculating one or more alternative designs and displaying the associated information.



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

- 1 -

INTEGRATED INTELLIGENT IRRIGATION SYSTEM DESIGN, IMPLEMENTATION AND MONITORING

TECHNICAL FIELD

[0001] The present invention relates to a irrigation system and more particularly relates to designing and managing the designed irrigation system with optimum efficiency.

BACKGROUND

[0002] The object of an irrigation system is to efficiently and effectively deliver the required amount of water, nutrient, and other inputs to the plant to achieve the desired production objective. The production objective can be varied, and can vary over time but includes maximizing yield, achieving optimal health and vigor of the plant, or delivering an acceptable outcome based on other constraints such as availability of inputs or other resources.

[0003] These optimizations of operation benefit greatly from monitoring the irrigation system whilst operating.

[0004] The physical water delivery system is usually designed first.

[0005] The physical water delivery system is usually designed to consider constraints such as cost of parts, availability and cost of water delivery, flow rates and other hydraulic and mechanical constraints and objectives.

[0006] The design does not consider the cost to own and operate.

[0007] The irrigation system design is not used post system installation. Information that is part of the design must be duplicated in other operational systems and can be in conflict with original design intent.

[0008] The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge.

- 2 -

SUMMARY

[0009] According to one aspect of the invention, it is possible to extend an irrigation system design phase to include the consideration of the cost and objectives of operational monitoring and automation and the total lifetime cost of ownership and operating of an irrigation system based on the subject design.

[0010] According to another aspect of the invention, there is provided functionality to incorporate the consideration of elements specific to operation, measurement, monitoring and automation of the irrigation system and optionally using machine learning and artificial intelligence to suggest improvements to the design to lower the total operating cost and improve the operational performance of the system.

[0011] In some aspects of the invention, an irrigation design is available in machine readable format in a way that includes all the operational constraints and objectives of the irrigation system relating to resource usage, operating conditions, crop information, operating objectives etc.

[0012] In some aspects of the invention, there is provided a computer operated software system, that can be embedded in irrigation controllers or hosted on servers and deployed in cloud environments that can access the irrigation system design in real time to achieve many new capabilities that can only be achieved with such access to a design in machine readable format. Such capabilities and novel applications include:

- a. Enhanced, configuration-free, automated reporting
- b. Machine-learning and AI-enhanced risk prediction and prevention

[0013] In some aspects of the invention there is provided a system and method of using the irrigation system design in machine readable format to assess the operational state of a currently operating irrigation system deployed in accordance with the design and to determine key operating characteristics and

assess the extent to which current operating conditions are within the design constraints and meeting the design objectives of the irrigation system design.

[0014] In some aspects of the invention, there is provided a system and method to use a machine readable irrigation system design to allow, automatically guide, and verify the development of a program of irrigation that will not violate any of the design constraints of objectives.

[0015] In another aspect of the invention, there is provided a system and method of using artificial intelligence and machine learning techniques to suggest, develop and improve irrigation programs that describe the desired operation of an irrigation system such that it will operate within the design constraints and objectives of the irrigation system design.

[0016] In another aspect of the invention, there is provided a system and method for alerting relevant stakeholders, in a variety of communications channels of key events during the operation of an irrigation program that uses the machine readable design, historical performance data, machine learning and artificial intelligence techniques to detect anomalous behaviour, and identify opportunities for direct manual and automatic intervention that will minimize and avoid problems and create more desirable outcomes when considering the irrigation system design and other objectives provided with the irrigation program.

[0017] In another aspect of the invention there is provided a system and method for the provision of an interactive query service, hosted in a variety of computational environments such as embedded controllers, computer servers and cloud based environments that can accept queries in a plurality of forms (written, spoken, visual etc) and apply that query to the machine readable irrigation system design, the current operating state of an irrigation system or program and allow a person and a system to collaborate and reason about the state of the system, the extent to which the system is considered to be operating with established design constraints and suggest, co-develop, extrapolate and implement actions and

- 4 -

changes to the irrigation program that will improve outcomes or avoid undesirable outcomes.

[0018] A system and method for the development and delivery of reports that summarise the operation of an irrigation program by referring to, collecting and summarising a combination of the irrigation system design, recorded operating data and predicted future state of the system, the operating environment and available resources to summarise the cost, time, usage and other characteristics of the program and to suggest automatic or manual improvements and other impacts of changes to the system, inputs, operating characteristics to achieve desirable outcomes and improve key characteristics such as economic performance, crop yield improvements, reduction in waste and exposure to risk of pest or disease.

[0019] Throughout this specification (including any claims which follow), unless the context requires otherwise, the word ‘comprise’, and variations such as ‘comprises’ and ‘comprising’, will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The detailed description is described with reference to the accompanying figures.

[0021] Figure 1 illustrates a schematic of exemplary irrigation system design process in accordance with the present disclosure.

[0022] Figure 2 illustrates a schematic showing an irrigation plan design process.

[0023] Figure 3 illustrates a schematic showing example irrigation operational monitoring service and interactions.

[0024] Figure 4 depicts an exemplary chatbot interaction in accordance with the present disclosure

- 5 -

[0025] Figure 5 is an example irrigation summary as illustrated in accordance with the present disclosure.

[0026] Figure 6 is another exemplary chatbot interaction in accordance with the present disclosure.

[0027] Figure 7 is an example weekly report as illustrated in accordance with the present disclosure.

[0028] Figures 8 to 10 as illustrated are example interactions with conversational irrigation monitoring and management service in accordance with the present disclosure.

[0029] Figure 11 is yet another exemplary chatbot interaction in accordance with the present disclosure.

DETAILED DESCRIPTION

[0030] It is convenient to describe the invention herein in relation to an exemplary embodiment. The invention is applicable to a wide range of implementations and it is to be appreciated that other constructions and arrangements are also considered as falling within the scope of the invention. Various modifications, alterations, variations and or additions to the construction and arrangements described herein are also considered as falling within the ambit and scope of the present invention.

[0031] According to one aspect of the invention, it is possible to extend an irrigation system design phase to include the consideration of the cost and objectives of operational monitoring and automation and the total lifetime cost of ownership and operating of an irrigation system based on the subject design (Figure 1).

[0032] Accordingly, one example implementation of the invention is a computer implemented method for designing an irrigation system comprising: receiving data associated with a proposed irrigation design; analysing a proposed

design, comprising one or more of: proposed measurements and automation requirements; retrieving one or more pre-established estimation rules from a data store; estimating additional measurement and automation requirements based on one or more such estimation rules; adjusting one or more estimation rules based on real data associated with operation of a previous and / or current irrigation system.

[0033] The method further comprises estimating one or more of acquisition, installation and operating costs based on one or more of: hardware costs; radio network propagation characteristics (optionally of terrain, crop, etc); other factors that have historically contributed to ownership cost;

[0034] displaying to a user one or more of such estimated costs;

[0035] calculating one or more alternative designs which optionally offer the same or similar hydraulic properties and outcomes and superior ownership costs; such calculation optionally based on 10 one or more of: changing placement of key infrastructure; and combining or splitting system elements to improve one or more economic and / or performance outcomes; and

[0036] displaying information associated with at least one of the calculated alternative designs.

[0037] According to another aspect of the invention, there is provided functionality to incorporate the consideration of elements specific to operation, measurement, monitoring and automation of the irrigation system and optionally using machine learning and artificial intelligence to suggest improvements to the design to lower the total operating cost and improve the operational performance of the system (Figure 1).

[0038] In some aspects of the invention, an irrigation design is available in machine readable format in a way that includes all the operational constraints and objectives of the irrigation system relating to resource usage, operating conditions, crop information, operating objectives etc (Figure 1).

- [0039]** In some embodiments this may comprise one or more of:
- a. Enhanced versions of existing software to extend file formats to include additional information 25
 - b. New XML or JSON formats which describe enhanced elements of irrigation system design
 - c. A cloud based repository for the exchange of meta-models that describe the ontology and allow for the specific modelling, storage and retrieval of files that encode and incorporate additional elements of irrigation system design. Current software can be enhanced to refer to these additional services by URI or other universal naming scheme locators.

[0040] In some aspects of the invention, there is provided a computer operated software system, that can be embedded in irrigation controllers or hosted on servers and deployed in cloud environments that can access the irrigation system design in real time to achieve many new capabilities that can only be achieved with such access to a design in machine readable format – see Figures 2, 3 and 4.

[0041] The ability to provide operational alerting and reporting without any need for configuration beyond reading the original design, dramatically simplifying setup and reducing costs of installation and operation

[0042] Allowing for machine-learning and artificial intelligence systems to monitor currently operating systems and predict the presence of operating conditions that have occurred or may occur in the future, significantly reducing risk, preventing costly damage and reducing costs of ownership and operation

[0043] Accordingly, in some embodiments, there is provided a computer implemented method of irrigation system design comprising:

- 8 -

[0044] receiving an input associated with a user request to add and or edit an irrigation schedule;

[0045] optionally adjusting the input to fit a predetermined template (to allow for simpler comparison);

[0046] accessing in machine readable format an irrigation design relevant to the irrigation schedule;

[0047] comparing the input (or the optionally adjusted input) with the accessed irrigation design;

[0048] determining whether the input characteristics are incompatible with one or more parameters of the accessed irrigation design (for example exceed design capacity);

[0049] calculating one or more probable user requirements from the input data;

[0050] optionally identifying one or more alternative irrigation schedule modifications to meet one or more of the probable user requirements and also meet one or more (preferably all) constraints associated with the accessed irrigation design; and

[0051] alerting a user to an incompatibility if identified and optionally to one or more such alternatives.

[0052] In some aspects of the invention there is provided a system and method of using the irrigation system design in machine readable format to assess the operational state of a currently operating irrigation system deployed in accordance with the design and to determine key operating characteristics and assess the extent to which current operating conditions are within the design constraints and meeting the design objectives of the irrigation system design (Figure 3).

[0053] Accordingly in some embodiments of the invention there is provided a computer implemented method of managing an irrigation system comprising:

[0054] receiving a user input with instructions to commence an irrigation program at a specified time and preferably a specified date, the irrigation program preferably comprising a given volume and other relevant characteristics;

[0055] requesting irrigation data in relation to said irrigation program from one or more physical devices associated with the program, the devices may for example optionally be a water meter; a pump, etc accessing in machine readable format an irrigation design relevant to the irrigation schedule;

[0056] comparing the requested irrigation data with the accessed irrigation design;

[0057] determining from the requested irrigation data whether the input characteristics are compatible with one or more parameters of the accessed irrigation design (for example design capacity);

[0058] on detecting an incompatibility, determining one or more proposed remedial actions based on the irrigation design;

[0059] requesting from a user (visually, by sound or an other suitable means) instructions in relation to the one or more proposed remedial actions;

[0060] receiving an input from a user associated with the one or more proposed remedial actions;

[0061] comparing the input data with the accessed irrigation design to identify an efficient (preferably most efficient) method of performing a remedial action; and

[0062] communicating an instruction in relation to a remedial action to one or more physical devices associated with the irrigation program.

[0063] In some aspects of the invention, there is provided a system and method to use a machine readable irrigation system design to allow, automatically guide, and verify the development of a program of irrigation that will not violate any of the design constraints of objectives (Figure 2).

[0064] Accordingly, in some embodiments, there is provided a computer implemented method comprising the steps:

[0065] presenting (optionally visually or verbally) to a user one or more possible irrigation elements based on a machine readable irrigation design, each element corresponding to a design feature which is configurable by user input, preferably such elements may be presented in a simple, easy to use format, such as building blocks to be put together in a range of ways to meet various irrigation design needs;

[0066] receiving input from a user in relation to one or more of said elements and a proposed irrigation program based on one or more of them;

[0067] in response to an input from a user, calculating an implied operational characteristic of the current proposed user design optionally by extracting key input from the machine readable irrigation design;

[0068] optionally simulating operation of an irrigation design for example by using the user supplied inputs in conjunction with one or more constraints associated with the irrigation design;

[0069] optionally alerting a user to an actual or possible incompatibility (for example violation of operating constraints) of the proposed design based on an output from the simulation.

[0070] In another aspect of the invention, there is provided a system and method of using artificial intelligence and machine learning techniques to suggest, develop and improve irrigation programs that describe the desired operation of an

irrigation system such that it will operate within the design constraints and objectives of the irrigation system design (Figures 2 and 3).

[0071] Accordingly, according to some embodiments of the invention, there is provided a computer implemented method comprising:

[0072] combining one or more machine readable irrigation design elements and one or more irrigation-relevant parameters (such as crop type, soil type, local precipitation, weather conditions, etc), the parameters having been obtained from one or more sources comprising: an irrigation design, current and / or historical operating and / or environmental conditions, site specific data, data from similar sites, etc combining one or more machine learning model and / or simulations to determine a likely plant soil and / or water requirement;

[0073] comparing the water requirement with one or more model outputs and optionally one or more other sources (such as historical data from the same and similar sites);

[0074] selecting a preferred model optionally using a statistical method, the preferred model representing the current soil and / or plant water needs and being combined with the operating design constraints of the irrigation system design;

[0075] proposing (visually, by audio or any suitable means) to a user a proposed irrigation plan intended to provide the estimated soil and / or water and nutrient requirements whilst operating the irrigation system within design constraints for operating characteristics such as water pressure, water available, energy availability, energy cost, and other economic incentives and constraints;

[0076] optionally requesting input in relation to the proposed irrigation plan from a user;

[0077] optionally receiving an input from a user, which may for example comprise acceptance, amendments to the plan (with or without further computer-generated guidance relating to the likely impact of changes proposed by the user.

[0078] In another aspect of the invention, there is provided a system and method for alerting relevant stakeholders, in a variety of communications channels of key events during the operation of an irrigation program that uses the machine readable design, historical performance data, machine learning and artificial intelligence techniques to detect anomalous behaviour, and identify opportunities for direct manual and automatic intervention that will minimize and avoid problems and create more desirable outcomes when considering the irrigation system design and other objectives provided with the irrigation program (Figure 3).

[0079] Accordingly, in some embodiments there is provided a computer implemented method comprising:

[0080] receiving or accessing data associated with operation of an irrigation system;

[0081] receiving or accessing data associated with an irrigation system plan associated with the said irrigation system;

[0082] comparing one or more parameters associated with operation of the system with the system plan and optionally also comparing with historical data associated with the system and other similar systems;

[0083] optionally using one or more statistical methods to predict the likelihood of certain operating characteristics exceeding design constraints or desirable limitations and conditions;

[0084] optionally comparing actual recorded operating conditions with the irrigation design and one or more other stated limitations;

[0085] optionally accessing and comparing information to determine an appropriate (preferably most appropriate) means of communication with stakeholders that have implicit or explicit stated interest in the operational state of the irrigation system;

[0086] optionally notifying via one or more selected methods one or more selected stakeholders with information about the operating state of the system, the potential or actual violation of certain operating constraints or the likelihood of such violation.

[0087] In another aspect of the invention there is provided a system and method for the provision of an interactive query service, hosted in a variety of computational environments such as embedded controllers, computer servers and cloud based environments that can accept queries in a plurality of forms (written, spoken, visual etc) and apply that query to the machine readable irrigation system design, the current operating state of an irrigation system or program and allow a person and a system to collaborate and reason about the state of the system, the extent to which the system is considered to be operating with established design constraints and suggest, co-develop, extrapolate and implement actions and changes to the irrigation program that will improve outcomes or avoid undesirable outcomes (figure 3).

[0088] Accordingly, in some embodiments, there is provided a computer implemented method comprising:

[0089] receiving or accessing data in relation to operation of an irrigation system;

[0090] in response to said data, offering to a user one or more choices of remedial action and one or more methods for indicating a selection amongst such choices;

[0091] receiving an input associated with a user's choice in relation to the offered remedial actions;

[0092] sending an instruction associated with the user input, for example to alter or stop operation of a physical device or to set a time limit, or to send further information, etc.

[0093] In some embodiments, a user may request form a system according to the invention in relation to the likelihood of a defined outcome occurring. In response to such a request, a processor may operate a method according to the invention and use a statistical method and optionally combine data from one or more sources to simulate, extrapolate or otherwise estimate the likelihood of the defined outcome and thereafter respond to the user with a response, which 30 may for example be an estimate.

[0094] In some embodiments, a processor and user may exchange several communications to develop a preferred course of action. And a user may indicate the preferred course of action and request the system undertake said action.

[0095] A system and method for the development and delivery of reports that summarise the operation of an irrigation program by referring to, collecting and summarising a combination of the irrigation system design, recorded operating data and predicted future state of the system, the operating environment and available resources to summarise the cost, time, usage and other characteristics of the program and to suggest automatic or manual improvements and other impacts of changes to the system, inputs, operating characteristics to achieve desirable outcomes and improve key characteristics such as economic performance, crop yield improvements, reduction in waste and exposure to risk of pest or disease.

[0096] Figure 7 is an example weekly report. Such a report may comprise any suitable data, for example some users may prefer per field data, or data highlighted for the largest fields, or those with the greatest variance, or highest probability of an incompatibility etc.

[0097] In some embodiments, data may be combined from various sources including but not limited to current and historical recording of irrigation system performance from this and other irrigation systems, machine-readable irrigation design and other configuration data, environmental data, crop models and other

sources of agronomic knowledge to determine the desired irrigation program and compare it to the recorded performance of the actual irrigation program.

[0098] In some embodiments, the system may combine data, extrapolations, simulations and other statistical methods to provide comparison of the subject irrigation plan to other plans and other comparable activities to place the information in a context of operating performance, statistical variation and comparative performance to other comparable systems and methods.

[0099] In some embodiments, the system may create written and visually represented reports to convey the actual performance and comparative, quantitative and qualitative assessment in a visual and written form than will be delivered to the User in a variety of formats and via a variety of channels.

We Claim:

1. A method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time, the method comprising:
 - a. receiving data associated with a proposed irrigation design;
 - b. analysing the proposed design, wherein the proposed design further comprises one or more proposed measurements and automation requirements;
 - c. retrieving one or more pre-established estimation rules from a data store, and mapping the retrieved estimation rule with the proposed design;
 - d. estimating additional measurement and automation requirements based on one or more such estimation rules;
 - e. adjusting one or more estimation rules based on real data associated with operation of a previous and / or a current irrigation system;
 - f. estimating one or more of acquisition, installation and operating costs based on one or more of: hardware costs; radio network propagation characteristics (optionally of terrain, crop, etc); other factors that have historically contributed to ownership cost;
 - g. displaying to a user one or more of such estimated costs;
 - h. calculating one or more alternative designs which optionally offer the same or similar hydraulic properties and outcomes and superior ownership costs; such calculation optionally based on one or more of: changing placement of key infrastructure; and combining or splitting system elements to improve one or more economic and / or performance outcomes; and
 - i. displaying information associated with at least one of the calculated alternative designs.

2. A method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time, the method comprising:
 - receiving an input as a user request to edit an irrigation schedule;
 - comparing the input with a template, wherein the template corresponds to the designed irrigation system and is updated real time;

- 17 -

determining whether the input characteristics are incompatible with one or more parameters of the template;

calculating one or more probable user requirements from the input data;

optionally identifying one or more alternative irrigation schedule modifications to meet one or more of the probable user requirements and also meet one or more constraints associated with the template; and

alerting a user to an incompatibility if identified and optionally to one or more such alternatives.

3. The method as claimed in claim 2, further comprises optionally adjusting the input to fit a predetermined template, wherein the template is selected for the specific designed irrigation system.
4. A method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time, the method comprising:
 - receiving a user input with instructions to commence an irrigation program at a specified time;
 - requesting irrigation data in relation to said irrigation program from one or more physical devices associated with the irrigation program, wherein at least one device is selected from a water meter, a pump; and
 - communicating the instruction to one or more physical devices associated with the irrigation program.
5. The method as claimed in claim 4, further comprises accessing a template with an irrigation design relevant to the irrigation schedule.
6. The method as claimed in claim 4, further comprises comparing the requested irrigation data with the accessed template.

- 18 -

7. The method as claimed in claim 4, further comprises determining from the requested irrigation data whether the input characteristics are compatible with one or more parameters of the accessed irrigation design.
8. The method as claimed in claim 7, further comprises on detecting an incompatibility, determining one or more proposed remedial actions based on the irrigation design.
9. The method as claimed in claim 8, wherein determining one or more proposed remedial actions further comprises:
 - requesting from a user instructions in relation to the one or more proposed remedial actions;
 - receiving an input from a user associated with the one or more proposed remedial actions; and
 - comparing the input data with the accessed irrigation design to identify an efficient method of performing a remedial action.
10. The method as claimed in claim 8, wherein determining one or more proposed remedial actions further comprises:
 - offering to a user one or more choices of remedial action and one or more methods for indicating a selection amongst such choices;
 - receiving an input associated with a user's choice in relation to the offered remedial actions;
 - sending an instruction associated with the user input.
11. A method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time, the method comprising:
 - receiving or accessing data associated with operation of an irrigation system;
 - receiving or accessing data associated with an irrigation system plan associated with the said irrigation system;
 - comparing one or more parameters associated with operation of the system with the system plan and optionally also comparing with historical data associated with the system and other similar systems;

optionally using one or more statistical methods to predict the likelihood of certain operating characteristics exceeding design constraints or desirable limitations and conditions;

optionally comparing actual recorded operating conditions with the irrigation design and one or more other stated limitations;

optionally accessing and comparing information to determine an appropriate means of communication with stakeholders that have implicit or explicit stated interest in the operational state of the irrigation system;

optionally notifying via one or more selected methods one or more selected stakeholders with information about the operating state of the system, the potential or actual violation of certain operating constraints or the likelihood of such violation.

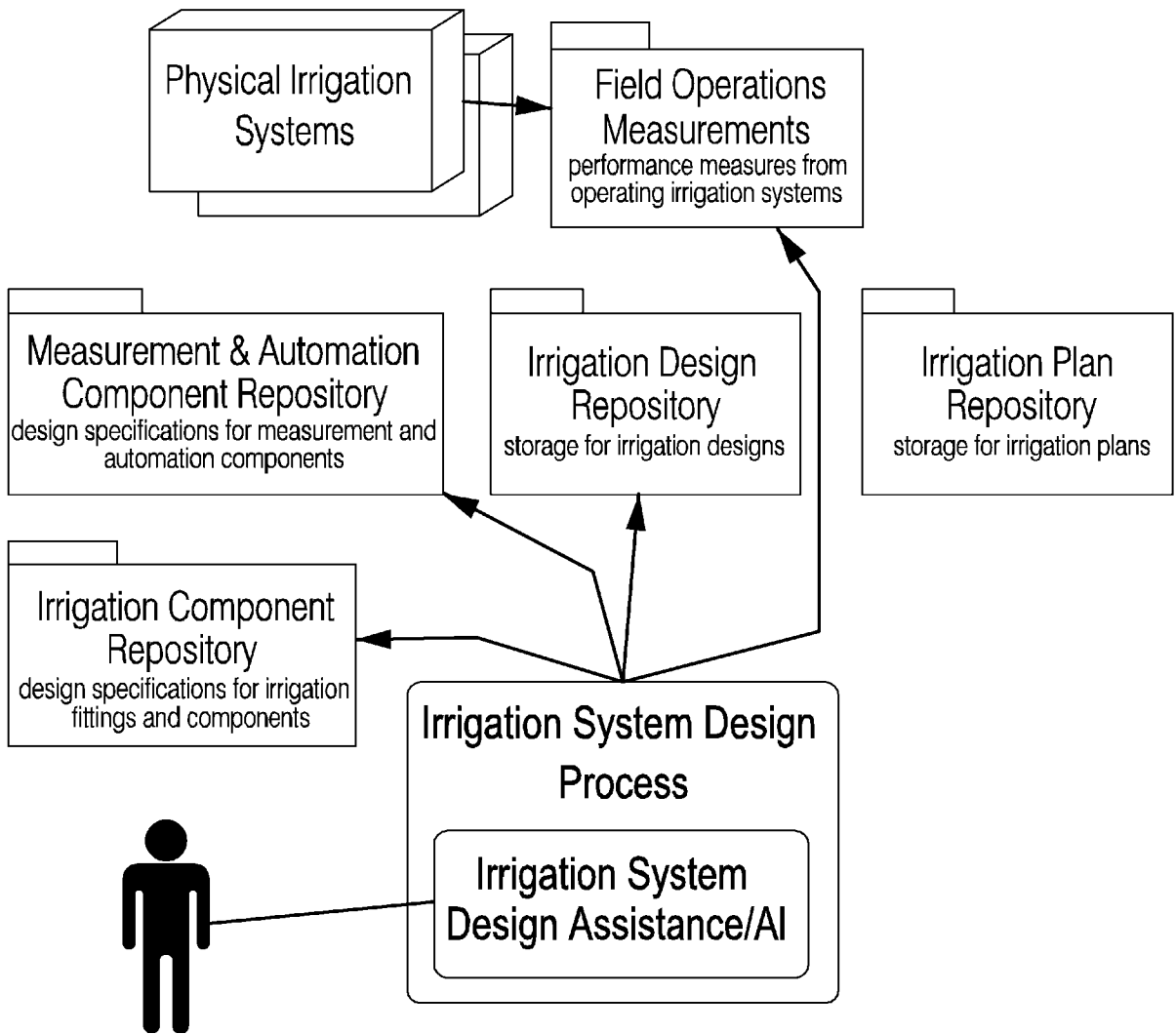


Figure 1

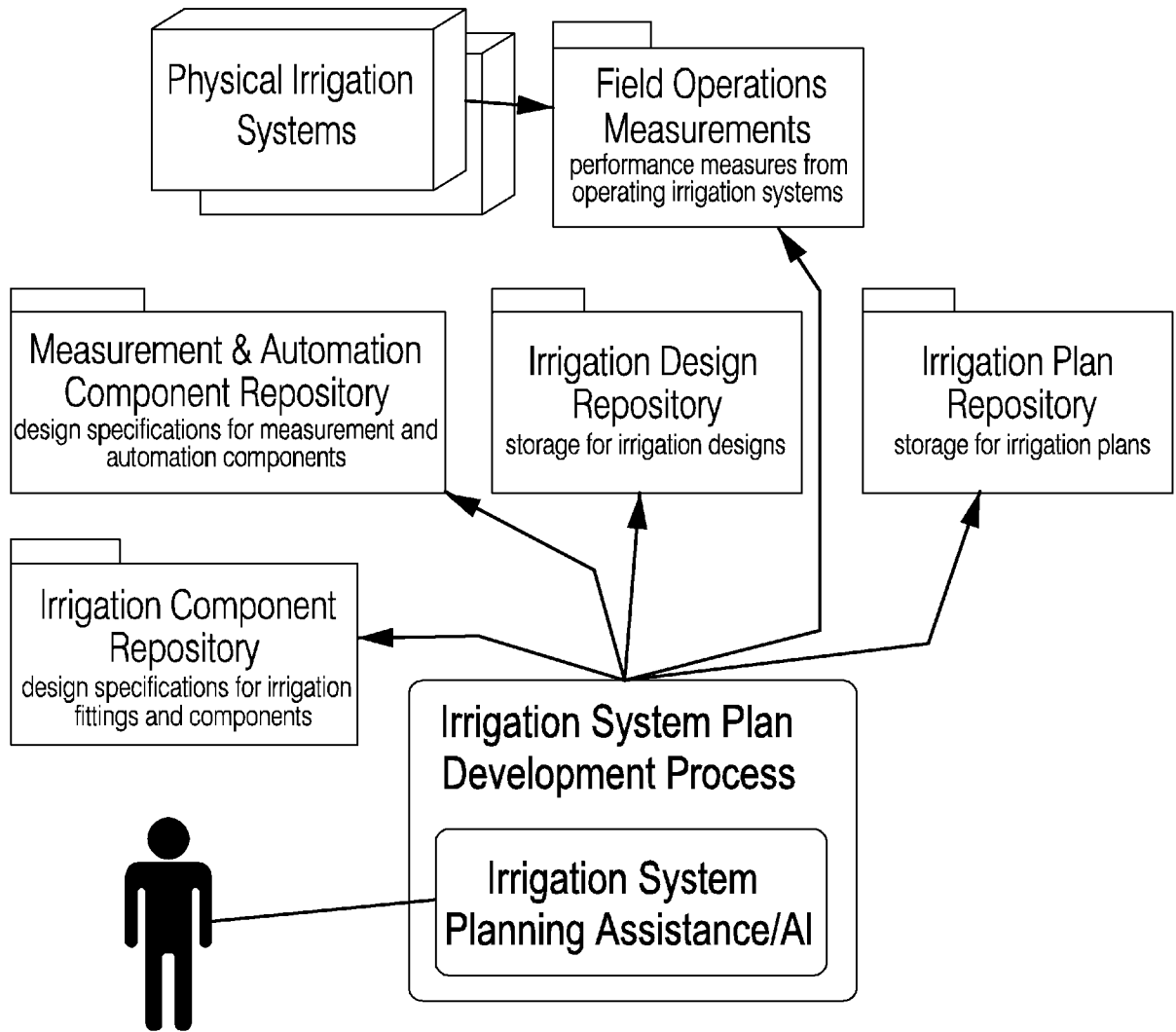


Figure 2

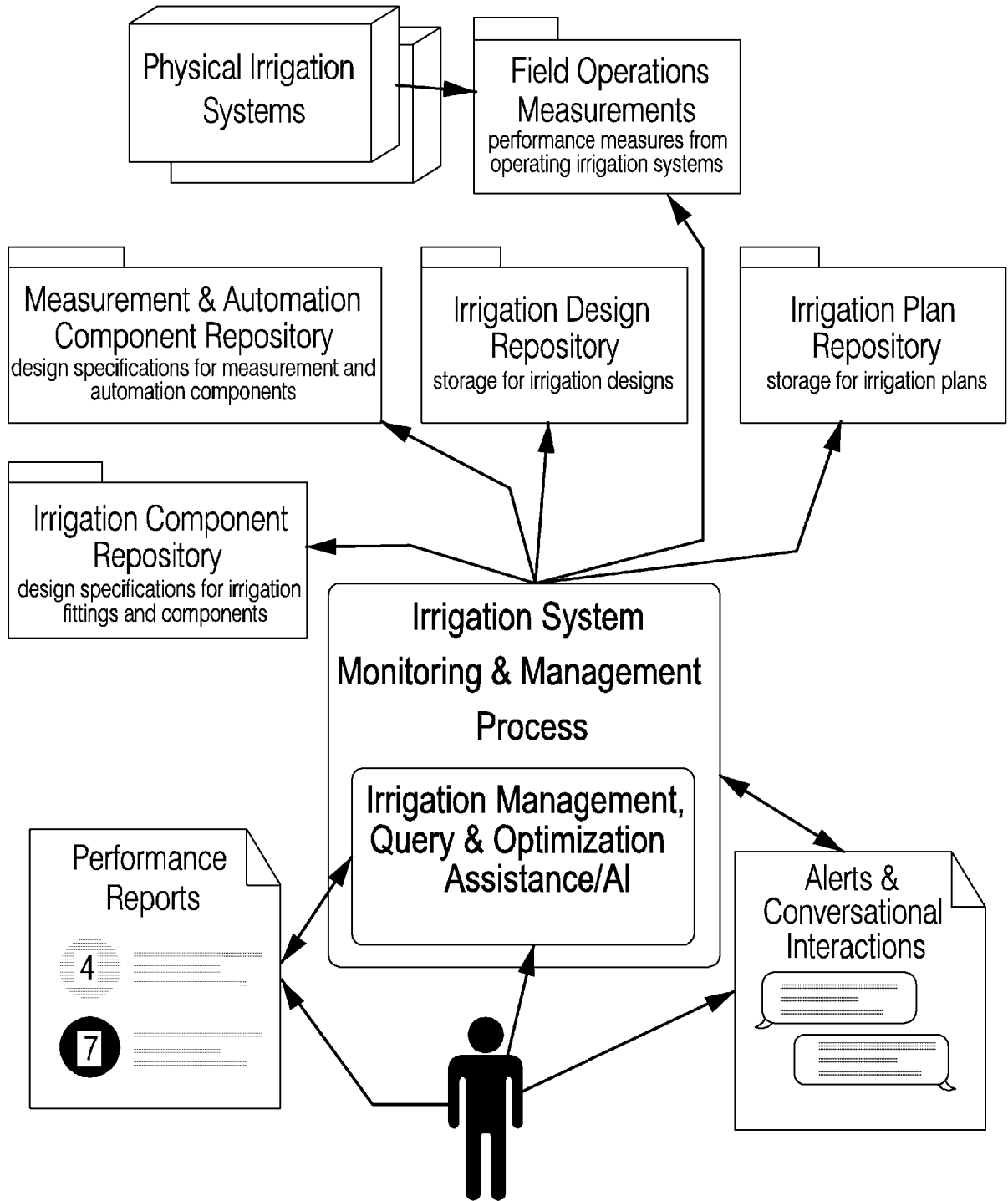


Figure 3

4/11

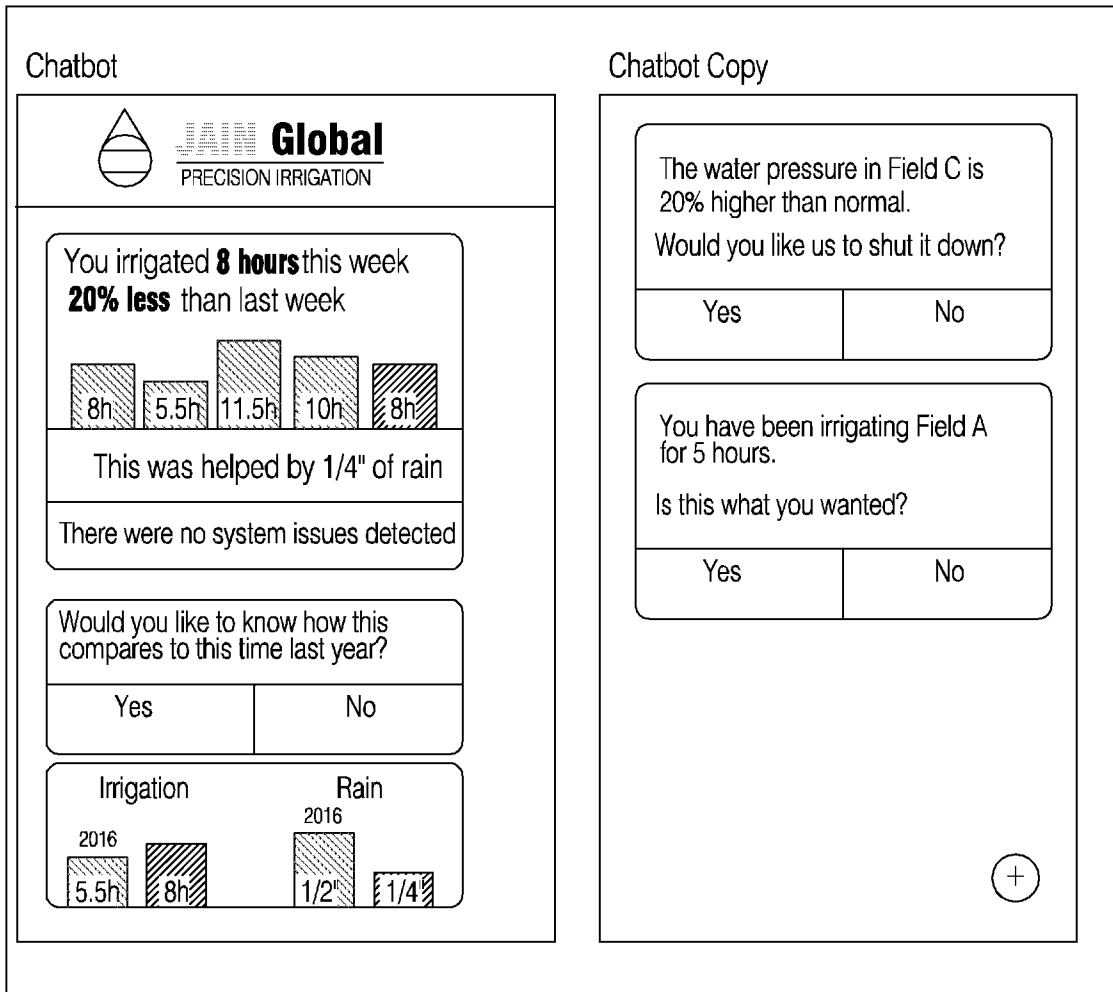


Figure 4

5/11

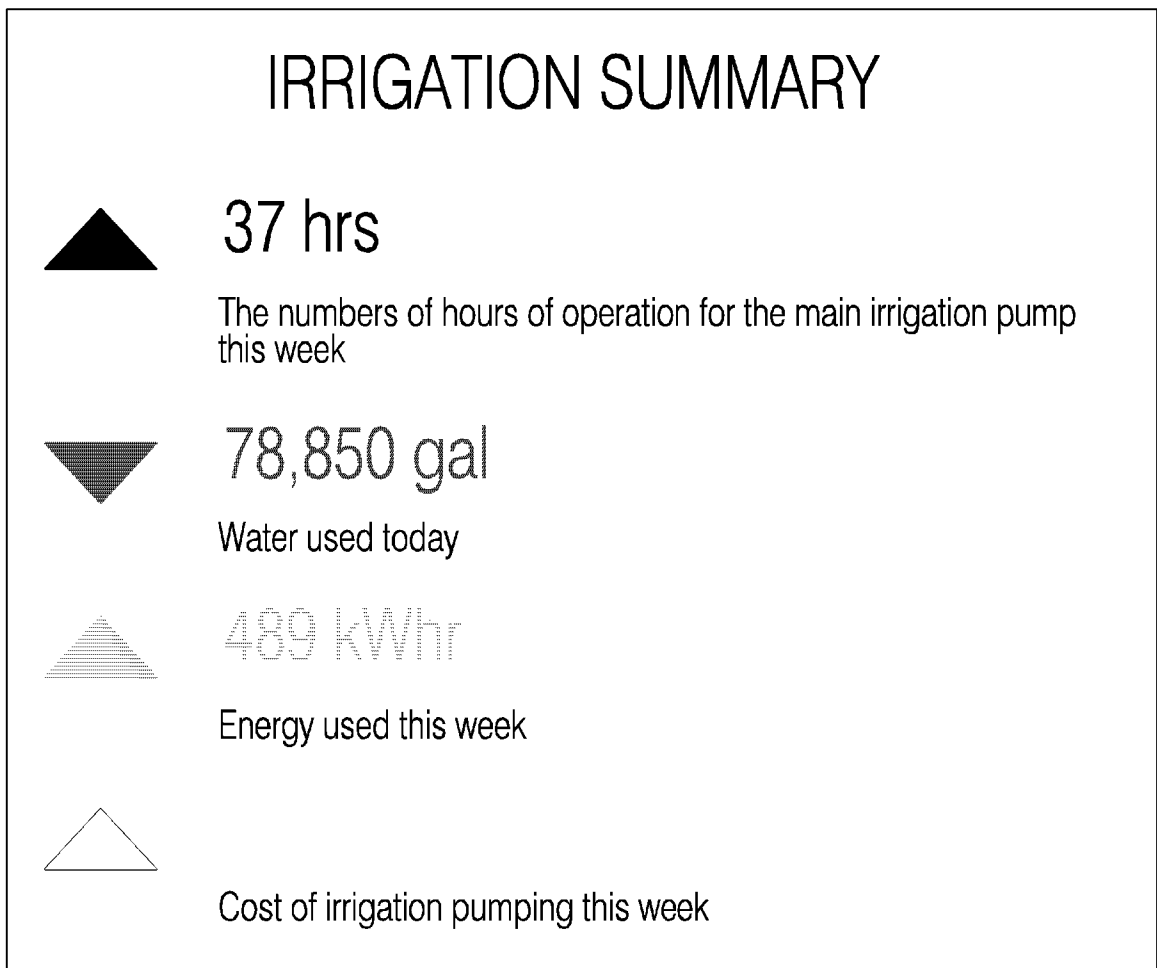


Figure 5

6/11

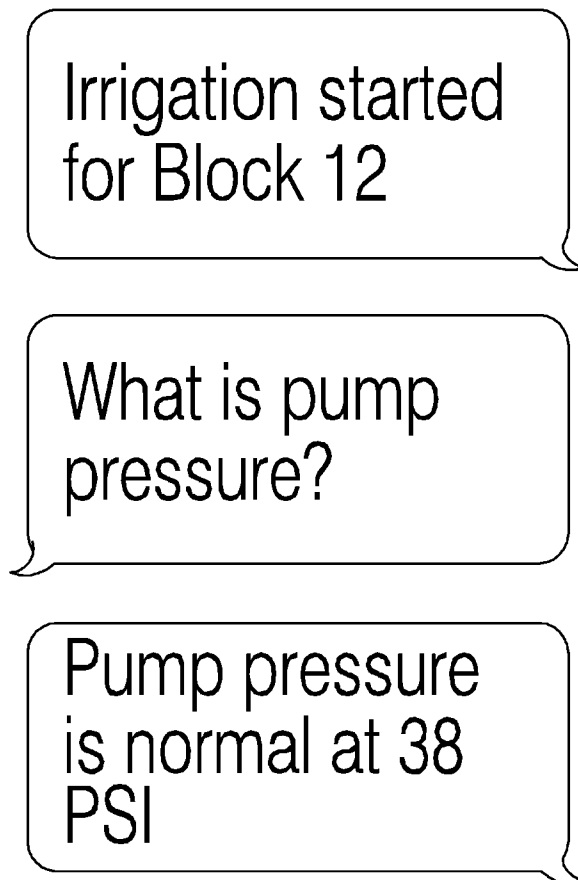


Figure 6

7/11

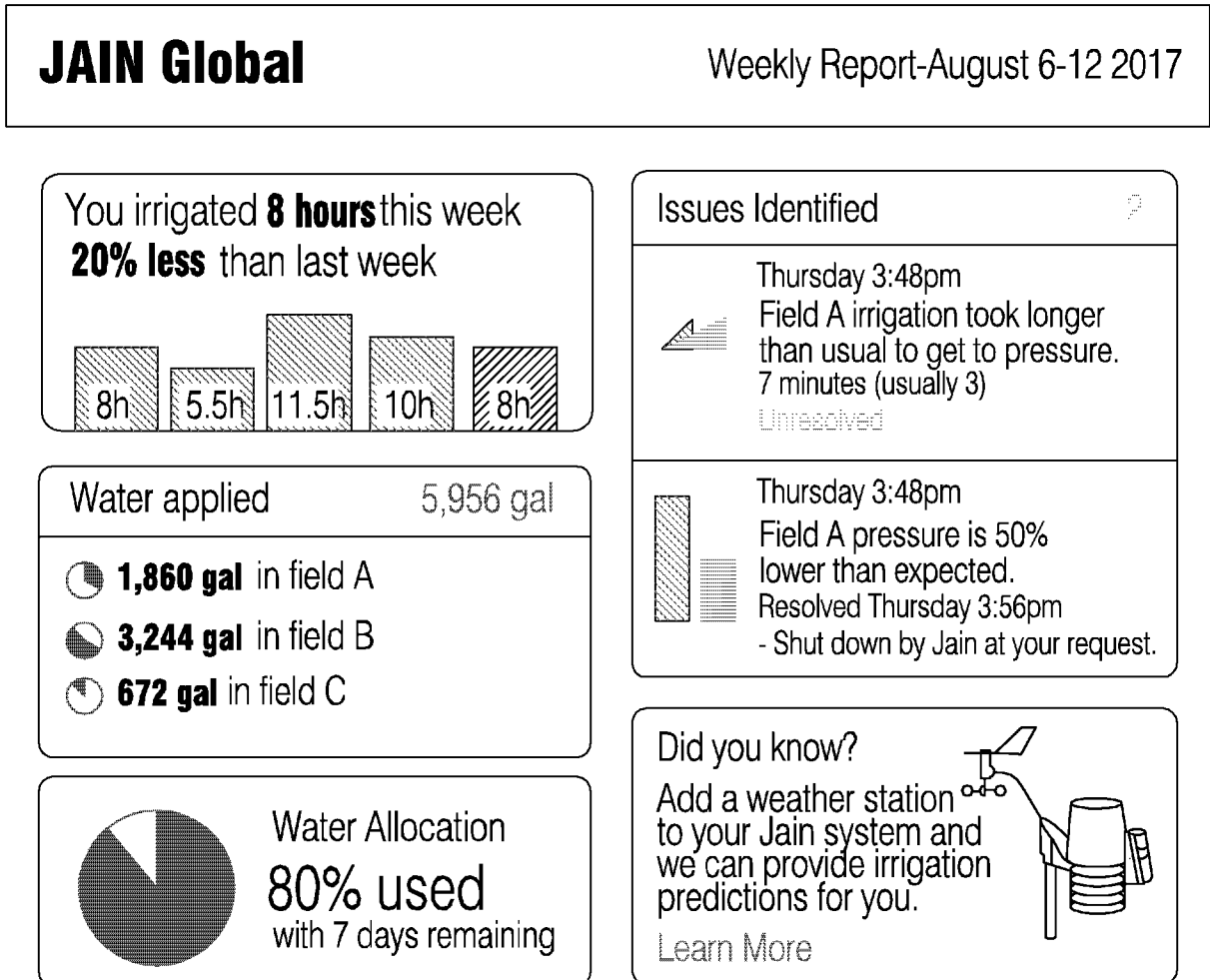


Figure 7

8/11

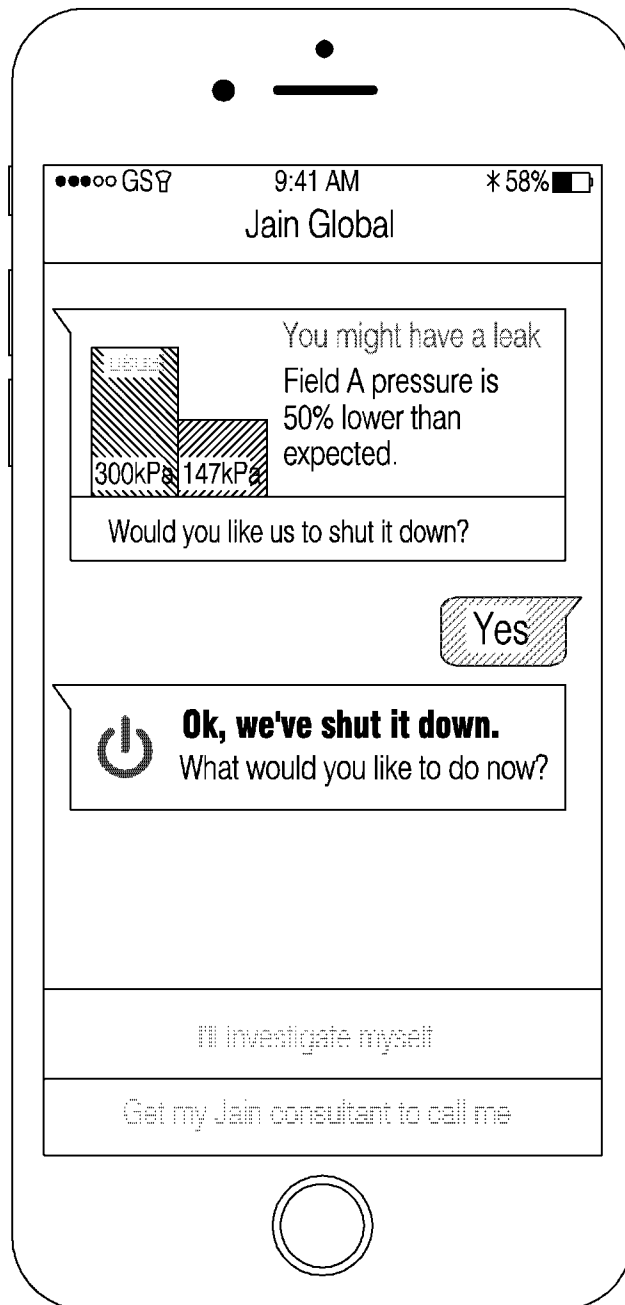


Figure 8

9/11

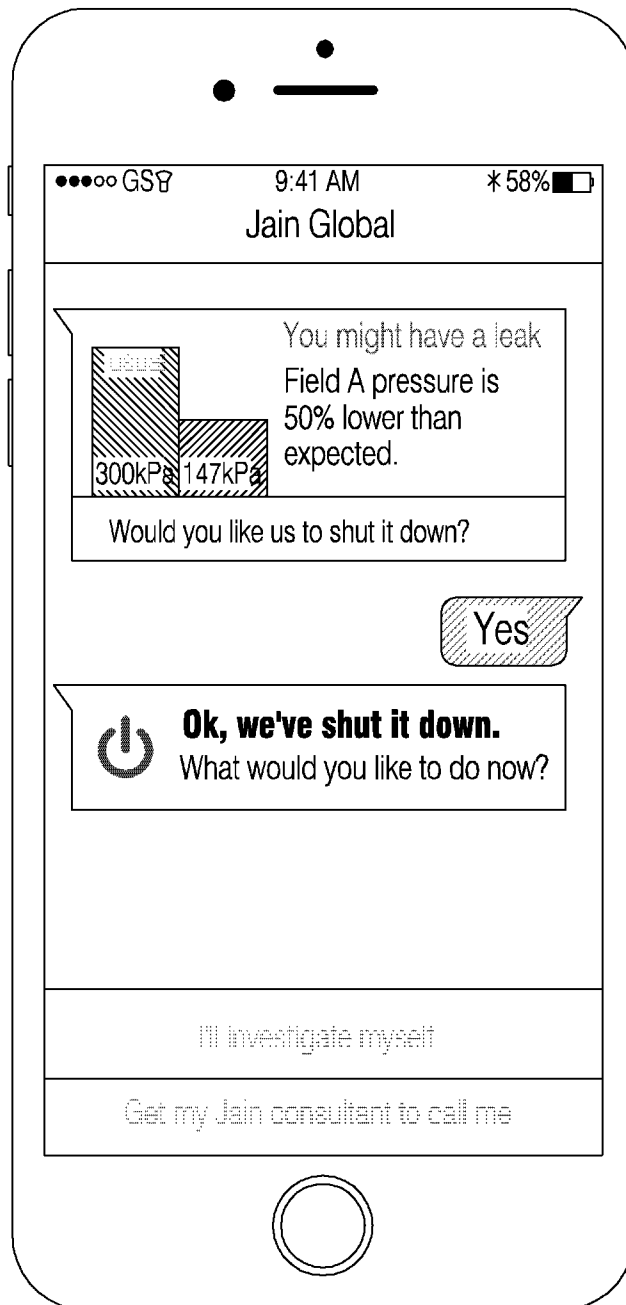


Figure 9

10/11

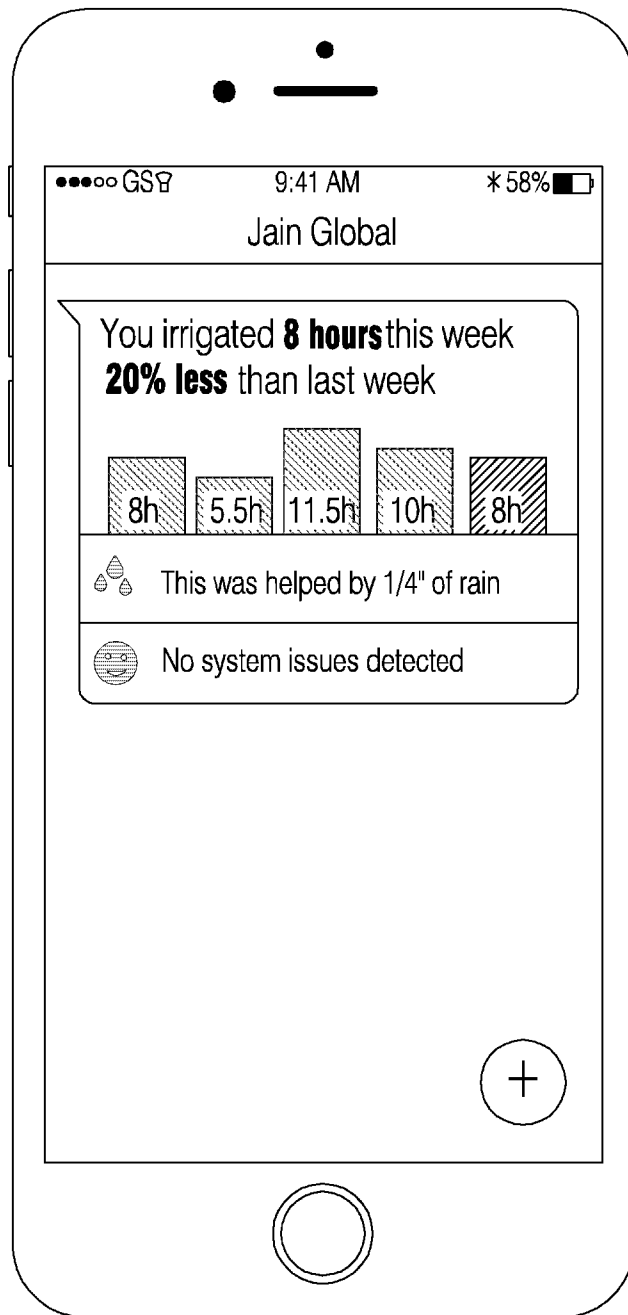


Figure 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2018/050990

A. CLASSIFICATION OF SUBJECT MATTER

G05B 13/04 (2006.01) G06Q 50/02 (2012.01) A01G 25/16 (2006.01) G05B 19/46 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases: PATENW, The LENS, Google Patents, Google, Google Scholar, Espacenet, AusPat and internal databases provided by IP Australia.**IPC/CPC Marks:** A01G25/16, G05B 13/04, G06Q50/02, G05B19/46.**Keywords:** Software, Optimal, Design, Irrigation, Agriculture, Farm, Crop, Manage, Operate, Data, Propose, Analyse, Measurements, Automation, Requirements, Pre-Established, Rules, Data Store, Mapping, Adjust, Previous, Current, Acquisition, Installation, Cost, Hardware, Radio Network Propagation, Terrain, Ownership, Display, Alternative, Hydraulic, Outcome, Key, Infrastructure, Improve, Economic, Performance, Real-time, Alternative, Template, Pilot, Model, Pressure, Flow, Protocol, Plural and like terms.**Applicant:** "Jain Agriculture Services". **Inventor:** "Pryor, James Matthew".

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| | Documents are listed in the continuation of Box C | |

 Further documents are listed in the continuation of Box C See patent family annex

| | | |
|---|-----|--|
| * Special categories of cited documents: | | |
| "A" document defining the general state of the art which is not considered to be of particular relevance | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "E" earlier application or patent but published on or after the international filing date | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "O" document referring to an oral disclosure, use, exhibition or other means | "&" | document member of the same patent family |
| "P" document published prior to the international filing date but later than the priority date claimed | | |

Date of the actual completion of the international search
9 January 2019Date of mailing of the international search report
09 January 2019**Name and mailing address of the ISA/AU**AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustalia.gov.au**Authorised officer**Yogita Chapre
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. (+612) 6222 3638

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

| INTERNATIONAL SEARCH REPORT | | International application No. |
|---|---|-------------------------------|
| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT | | PCT/AU2018/050990 |
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | <p>ROLIM, J. et al., 'The Design and Evaluation of Travelling Gun Irrigation Systems: Enrolador Software', Technical Paper in Journal of the Brazilian Association of Agricultural Engineering, Vol. 36, No. 5, Pages 917-927, published 2016, [retrieved from internet on 7 January 2019] <URL: http://www.scielo.br/scielo.php?pid=S0100-69162016000500917&script=sci_abstract >.</p> <p>Whole Document, in particular: Pages 917, 919-923, 925, Figures 2 and 4.</p> | 1 |
| X | <p>US 9202252 B1 (STEPHEN W. SMITH et al.) 01 December 2015</p> <p>Whole Document, in particular: Abstract; Col. 1, Lines 23-36; Col. 3, Lines 17-63; Col. 8; Col. 10, Line 19 – Col. 12, Line 23; Col. 14, Line 53 – Col. 17, Line 35; Figures 1, 3 and 6-13.</p> | 1 |
| A | <p>HOLZAPFEL, E. A. et al., 'Design and Management of Irrigation Systems', Article in Chilean journal of agricultural research, December 2009, [retrieved from internet on 7 January 2019]</p> <p><URL: http://www.chileanjar.cl/files/V69_ISpecial%20Edition_2009_ENG_EduardoA_Holzapel.pdf >.</p> <p>Whole Document.</p> | 1 |
| A | <p>IRRIGATION AUSTRALIA, 'Irrigation System Design Guidelines', Version 6, Published 16 February 2017, [retrieved from internet on 7 January 2019]</p> <p><URL: https://www.irrigationaustralia.com.au/documents/item/434 >.</p> <p>Whole Document.</p> | 1 |
| A | <p>INMAN-BAMBER, G. et al., 'Inventory of Australian Software Tools for On Farm Water Management', Cooperative Research Centre for Irrigation Futures, Technical report no. 02/05, Published May 2005, [retrieved from internet on 7 January 2019]</p> <p><URL: https://www.irrigationaustralia.com.au/documents/item/217 >.</p> <p>Whole Document.</p> | 1 |

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claim 1 is directed to a method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time. The feature of receiving data associated with a proposed irrigation design; analysing the proposed design, wherein the proposed design further comprises one or more proposed measurements and automation requirements; retrieving one or more pre-established estimation rules from a data store, and mapping the retrieved estimation rule with the proposed design; estimating additional measurement and automation requirements based on one or more such estimation rules; adjusting one or more estimation rules based on real data associated with operation of a previous and / or a current irrigation system; estimating one or more of acquisition, installation and operating costs based on one or more of: hardware costs; radio network propagation characteristics (optionally of terrain, crop, etc); other factors that have historically contributed to ownership cost; displaying to a user one or more of such estimated costs; calculating one or more alternative designs which optionally offer the same or similar hydraulic properties and outcomes and superior ownership costs; such calculation optionally based on one or more of: changing placement of key infrastructure; and combining or splitting system elements to improve one or more economic and / or performance outcomes; and displaying information associated with at least one of the calculated alternative designs is specific to this group of claims.
- Claims 2-3 are directed to a method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time. The feature of receiving an input as a user request to edit an irrigation schedule; comparing the input with a template, wherein the template corresponds to the designed irrigation system and is updated real time; determining whether the input characteristics are incompatible with one or more parameters of the template; calculating one or more probable user requirements from the input data; optionally identifying one or more alternative irrigation schedule modifications to meet one or more of the probable user requirements and also meet one or more constraints associated with the template; and alerting a user to an incompatibility if identified and optionally to one or more such alternatives is specific to this group of claims.
- Claims 4-10 are directed to a method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time. The feature of receiving a user input with instructions to commence an irrigation program at a specified time; requesting irrigation data in relation to said irrigation program from one or more physical devices associated with the irrigation program, wherein at least one device is selected from a water meter, a pump; and communicating the instruction to one or more physical devices associated with the irrigation program is specific to this group of claims.
- Claim 11 is directed to a method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time. The feature of receiving or accessing data associated with operation of an irrigation system; receiving or accessing data associated with an irrigation system plan associated with the said irrigation system; comparing one or more parameters associated with operation of the system with the system plan and optionally also comparing with historical data associated with the system and other similar systems; optionally using one or more statistical methods to predict the likelihood of certain operating characteristics exceeding design constraints or desirable limitations and conditions; optionally comparing actual recorded operating conditions with the irrigation design and one or more other stated limitations; optionally accessing and comparing information to determine an appropriate means of communication with stakeholders that have implicit or explicit stated interest in the operational state of the irrigation system; optionally notifying via one or more selected methods one or more selected stakeholders with information about the operating state of the system, the potential or actual violation of certain operating constraints or the likelihood of such violation is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is a method for optimally designing an irrigation system and managing/ operating the designed irrigation system in real time, the method comprising receiving data.

Supplemental Box

However it is considered that this feature is generic in this particular art. Therefore in this light this common feature cannot be a special technical feature. Hence there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2018/050990

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document/s Cited in Search Report | | Patent Family Member/s | |
|---|-------------------------|-------------------------------|-------------------------|
| Publication Number | Publication Date | Publication Number | Publication Date |
| US 9202252 B1 | 01 December 2015 | US 9202252 B1 | 01 Dec 2015 |
| | | US 9569803 B1 | 14 Feb 2017 |

End of Annex