4000126063/18/NL/MP
NAVISP-EL3-001

MarRINav
MARITIME RESILIENCE AND INTEGRITY OF NAVIGATION

D9 Stakeholder Engagement Report

28th February 2020

MarRINav
MARITIME RESILIENCE AND INTEGRITY OF NAVIGATION

esa

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MarRINav – Maritime Resilience and Integrity in Navigation
Work Package 6 Stakeholder Engagement Report

Version	Date	Author	Reason for change
1.0	12.21.2019	B Cockshott	Initial Submission
2.0	28.02.2020	B Cockshott	Response to RIDS

Document Information

Client	ESA
Project Title	MarRINav – Maritime Resilience and Integrity in Navigation 4000126063/18/NL/MP NAVISP-EL3-001
Deliverable Number	D9
Report Title	WP6
Report Version	V2.0
Report Date	28th February 2020
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Circulation	1. Client 2. Project Files
File Name	20 02 28 D9 Shareholder Engagement Report v2.0.docx
File Location	Googledrive/Dropbox

Summary

This report summarises the activities undertaken in Work Package 6, Stakeholder Engagement, and in particular collates the outputs from the Stakeholder Engagement Workshop (15th May 2019) and the Dissemination Workshop (5th December 2019). The workshops and this document (Stakeholder Engagement Report, D9) are the main contractual deliverables from WP6.

Additional ad hoc opportunities were seized whenever possible to increase outreach and raise awareness.

Although not a specific contractual requirement, a web site set up by NLAI with GLA funding was supported in WP6. This has proved a valuable mechanism to share the findings of the project and to make the deliverable reports openly available in the public domain.

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Glossary

EGNOS	European Geostationary Navigation Overlay Service
ESA	European Space Agency
ETA	Expected Time of Arrival (at port)
CDM	(Port) Coordinated Decision Making
CNI	Critical National Infrastructure
CP	Container Ports
ECDIS	Electronic Chart Display and Information System
EEZ	Exclusive Economic Zone
EGNOS	European Geostationary Navigation Overlay System
ETA	Expected Time of Arrival
FDE	Fault Detection and Exclusion
GDPR	General Data Protection Regulation
GLA	General Lighthouse Authorities of the UK and Ireland
GSA	European Global Satellite system Agency
GNSS	Global navigation Satellite System
IALA	International Association of Lighthouse Authorities
IEC	International Electrotechnical Commission
IMO	International Maritime Organisation
IP	Intellectual Property
KTN	Knowledge Transfer Network
MASS	Marine Autonomous Surface Ships
MF	Medium Frequency
MSR	Multi Constellation Multi System Receiver
NTC	National Timing Centre
NPL	National Physical Laboratory
PNT	Position, Navigation, & Timing
PNTC	PNT Committee of techUK/UKSpace
R&I	Resilience and Integrity
R-Mode	Ranging Mode
RAIM	Receiver Autonomous Integrity Monitoring
RIMS	EGNOS Ranging and Integrity Monitoring Stations
RIN	Royal Institute of Navigation
SBAS	Satellite Based Augmentation System
SG	Steering Group
SLAM	Simultaneous Location and Mapping
SoW	Statement of Work
ToRs	Terms of Reference
UTC	Universal Time Coordinated
UK	United Kingdom
VDES	VHF Data Exchange System
VHF	Very High Frequency
WP	Work Package

1 Introduction, activities and outputs

This report summarises the MarRINav Phase 1 project's WP6 activities and contains reports outlining the outputs from the Stakeholder Engagement Workshop (15th May 2019) and the Dissemination Workshop (5th December 2019). The Stakeholder Engagement Plan (internal deliverable only) is attached as Appendix 1 to describe the scope and activities of the WP.

The two stakeholder workshops provided valuable opportunities to consult a wide range of organisations and individuals across industry, academia and the public sector on the challenges posed by GNSS vulnerabilities and the UK solution approaches. They facilitated a diverse feedback from sector experts – including key users such as mariners, port operators and pilots. This feedback enriched the project's information about the user needs, system requirements and interactions, the technologies and the system-of-systems analysed for effective provision of resilience and integrity (R&I) of maritime (and wider sector) Positioning, Navigation and Timing (PNT). Consultation and feedback was particularly helpful on the expected performance capabilities of the UK solution options and their predicted service coverage areas.

The KTN (as lead of WP6) and all MarRINav project partners gratefully acknowledge the time and inputs contributed by all stakeholders who attend one or both workshops.

1.1 Background

The MarRINav project is funded by ESA NAVISP Element 3 and responds to the UK Government Blackett Review on GNSS Vulnerabilities and the need for improved resilience of PNT. The studies have also been conducted in the context of the London Economics report which estimated the cost to the UK of a complete loss of GNSS for 5 days as £5.1B, of which 21% was attributed to the maritime sector (including ports).

The MarRINav project has focused on maritime R&I of PNT solutions for UK CNI, but potentially with wider applicability to other sectors where possible. It has examined a system-of-systems conceptual architecture (both geographical and operational) to deliver R&I of PNT as aids-to-navigation services which both support a spread of future e-Navigation services and utilise basic e-Navigation constructs to deliver PNT related information to vessels.

Users and their interaction with the PNT services considered by MarRINav are fundamental to the operational concept of the solution, covering the ubiquity of PNT information needs across many applications that affect the safe and efficient passage of ships, their manoeuvres approaching and inside ports and the transfer of cargo through the ports. Human factors, the portrayal of PNT and associated information and the utility of PNT data in downstream user applications are recognised as being very important to the success of solutions. PNT must be trustworthy and applied within the limits of its capability, highly available even in GNSS disrupted environments and with clear indications of its uncertainty bounds (possibly conveyed as error ellipses or a 'pool of errors' familiar to experienced navigators).

The interaction of the MarRINav solution concept with users, wider stakeholders and their applications at all stages of the PNT research and development is therefore crucial. The WP6 stakeholder engagement plan (Appendix 1) was generated to meet this objective and the two stakeholder workshops (reported in Sections 2 and 3) have been the central pillars of that plan.

1.2 Outputs

The WP6 outputs comprise:

- Engagement Plan – internal deliverable (attached as Appendix 1 for information)
- Contact list with GDPR permissions, currently with 60 members. Anyone can join this list using a link on the MarRINav web site.
- Email newsletters to stakeholders issued externally – two were delivered during the project. The contact list can continue to be used to send newsletters in future.
- Web site created by NLAI with GRAD support - https://marrinav.com
- Ad hoc outreach opportunities that have arisen throughout the duration of the project, but not all foreseen at the start of the project.
- Stakeholder Engagement Workshop (15th May 2019), 30 delegates.
- Engagement Workshop summary report – incorporated in this report, see section 2.
- Dissemination Workshop (5th December 2019), 30 delegates.
- Dissemination Workshop summary report – incorporated in this report, see section 3.
- Stakeholder Engagement Report (this report) – contractual deliverable D9.

1.3 Additional Activities

WP6 has supported several additional activities for outreach and communication of the project's objectives and results. These include:

1. The MarRINav project web site has been supported, in particular with the provision of links to background reports and deliverable documents.

2. A MarRINav presentation was given to the Royal Institute of Navigation (RIN) Technical Committee (~20 senior navigation community members) on 27th March 2019.

3. An article on MarRINav was published in July 2019 in RIN's *Navigation News*, a magazine distributed to all 2,000 RIN members.

4. MarRINav presented to the techUK/UK Space Position, Navigation and Timing Committee (PNTC) in April 2019. This comprises ~20 senior space and PNT industry delegates, plus some government representatives including the UK Space Agency and the GLA.

5. A meeting was held at NPL on 16th May 2019 to explore future collaboration on the sourcing of precise time (UTC) and its distribution to maritime and wider users, including the possible use interactions of the proposed National Timing Centre (NTC) with MarRINav system elements such as eLoran transmission synchronisation and the use of TV tower guy wires for eLoran onward transfer of precise time to VDES R-Mode transmitters and non-maritime users. NPL are expected to be an important contributor to follow-on activities in MarRINav Phase 2, if this proceeds.

6. WP6 also contributed to a MarRINav poster which was displayed at the UK Space Conference in Newport from 24th - 26th September 2019.

7. A paper on MarRINav was presented by the KTN at the Royal Institute of Navigation's International Navigation Conference (INC) in Edinburgh on 20th November 2019, which had ~100 delegates, mostly comprising senior people active in the navigation community.

2 First stakeholder engagement workshop summary report

The first MarRINav stakeholder engagement workshop was held on 15 May 2019 at the KTN in Islington, London. It was advertised openly to the public without restriction on attendance and free of charge.

2.1 Workshop organisation

2.1.1 Workshop Objectives

The workshop was established to:

- Explain the project's objectives and approach thus promoting awareness of the activity and the wider issues of resilient PNT in the maritime domain.
- Learn from stakeholders about current capabilities and the technology maturity of emerging systems.
- Identify gaps in capability affected by PNT integrity and resilience.
- Consult the maritime user community on the project approach.
- Identify priorities in PNT R&I requirements and capability gaps.
- Identify operational risks (safety, efficiency and environmental impact).

2.1.2 Delegates

The workshop gathered together 30 stakeholders from the maritime sector for a day of discussion and facilitated sessions.

Expertise in the room included:

- Commercial shipping
- Government and regulation in maritime
- Ports (ship-to-shore information exchange)
- Mariners
- Pilots
- Navigation and positioning
- PNT vulnerability and resilience
- Cyber security
- Aids to navigation
- Hydrographic survey
- Vessel operators

The workshop identified the following topics where the project would benefit from additional expertise:

- Autonomy (vessels and port systems)
- Use of precise timing in maritime (vessels and port systems)
- Landside infrastructure in ports and its GNSS dependency

2.1.3 Agenda

- Introduction
- The challenge of resilience & integrity (R&I) for maritime PNT
- Use Cases and Scenario of a container ship's voyage and cargo transfer in port
- Workshop organisational methodology – open space workshop
- Open space 1 – maritime user needs, requirements and systems using PNT
- Plenary discussion of open space 1
- Open space 2 – resilient PNT backup solutions and wider considerations
- Plenary discussion of open space 2
- Summary of workshop findings

2.1.4 Approach

The day was separated into an initial briefing and then two facilitated open space activities, each of which was divided into 3 groups covering different Use Cases within the voyage, as follows:

- Ocean voyage phase to anchorage at a holding point in the vicinity of a port
- Leaving anchorage, through port approach to the vessel's manoeuvres in port
- Vessel berthing, cargo unloading and cargo transfer to the port gate

These groups represented the journey of cargo on board a vessel from open ocean to the leaving the port gate. This journey is representative of the value chain elements within the maritime domain and covers the Scenario and it Use Cases identified in WP1. Delegates were invited to join any group they wished to and could move between groups if they felt they wanted to contribute to or learn from more than one. Each group was facilitated by a member of the MarRINav project team.

2.1.5 'Open space' workshop part 1 (1 hour)

The first open space activity focussed on user needs, requirements and systems. This activity was designed to extract insights from delegates that the project team in isolation may not have uncovered.

2.1.6 'Open space' workshop part 2 (1 hour)

The second open space activity focussed on back-ups and wider considerations. This activity was designed to tap into the knowledge of delegates and their creativity with a view to informing an understanding of existing levels of resilience and possible future solutions.

2.2 Summary of outcomes from the first workshop

The summary below is taken from facilitator notes and the open space group flip charts.

2.2.1 Current practice

1. IMO requirements do not mandate GNSS carriage, but data from an electronic position system (EPFS) may be essential for compliance and reporting, without which ships may not be allowed to sail.

2. GNSS inaccuracies can occur which are sufficiently large to affect safety but not so large as to be immediately noticeable by the mariner, whilst the GNSS bridge applications may not alarm giving rise to hazardously misleading information.

3. For larger GNSS errors, multiple bridge systems may alarm simultaneously leading to sensory overload of the mariner.

4. Principal backup systems to GNSS are terrestrially based, some with fairly limited coverage range, but there are more PNT alternatives to GNSS close to shore, e.g. radar and VDES R-Mode.

5. Dependence of ships' internal systems on GNSS timing and the distribution of positioning information is not well understood, since vessels typically have multiple GNSS receivers each feeding many different applications, with the ships' architecture not always fully documented in terms of GNSS use. An example of this is separate GNSS receivers used for the AIS (future VDES) carriage equipment and the primary navigation of the vessel as portrayed on the ECDIS. Protecting one system with resilient PNT may not protect other systems, depending on the variable data connections within the ship system's architecture.

6. Relative immaturity of port coordinated decision making (port CDM) and e-navigation services for ship-to-shore information exchange inhibits the situational awareness picture available to port operators.

7. Inefficient use of port berth / cargo storage capacity and ship delays may occur due to lack of port awareness of the ship's position, intended route and ETA.

8. Limited information (such as intended route and ETA) conveyed to ports from ships is available only to the immediately next port of call and further ports in the voyage plan do not receive that information, hence ports often receive information too late.

9. Generally, end-to-end cargo or container tracking is not in place throughout the journey (from ocean, interlining at ports and through to the hinterland). It was also noted that port theft is endemic and the insurance situation limits value and types of cargo going by sea. Cargo tracking using resilient PNT data could change this situation.

10. Inefficient steaming (with unnecessary levels of emissions and fuel burn) by ships unaware of port and dock availability may arise from lack of advanced information from port.

11. Almost all mobile port infrastructure, principally straddle carriers, are thought to be the most dependent on GPS.

2.2.2 Future to 2030

1. Autonomous vessels will never rely on GNSS alone for general navigation.

2. Standards for autonomous vessels may need to be higher than for manned vessels, which is being investigated under current IMO scoping study into the impacts of marine autonomous surface ships (MASS) on the regulatory framework, scheduled to report in late 2019/early 2020.

3. Optical positioning techniques are promising for the future (e.g. cameras with image processing, SLAM techniques and digital position – c.f. ePelorus).

4. Potential use of automated-celestial positioning.

5. 5G may supplement GNSS timing (Note: 5G may have some inherent vulnerabilities to GNSS timing and its range limitations may inhibit maritime use).

6. Portable atomic clocks, gravity sensors and quantum inertial sensors may eventually supplement GNSS and PNT backup systems.

7. Large scale renewable energy generation and fish farms will take more sea space.

8. Polar routes may become feasible for navigation throughout the year, noting the Russian fleet of nuclear icebreakers in the 2030 timescale accompanying ships along the northern sea route (for a fee).

9. Autonomous drones will have an intermodal role (e.g. inspection of containers on ships approaching ports).

10. Floating offshore habitation may be necessary to mitigate loss of land from rising sea levels.

11. Cargo condition monitoring will be increasingly important, including traceability of ports and environments.

12. On-board manufacturing within ships in transit will increase (e.g. fish processing).

13. More data bandwidth will be needed. Data flow will increase for customs pre-clearance (e.g. EU's e-maritime and e-customs concepts and application single windows).

14. Less bulk fuel will be transported.

15. Port handling will use more automation.

16. AI will be used increasingly for anomaly detection in cargo / paperwork / vessel activity.

17. Business models for ports may become more vertically integrated in supply chains, e.g. Amazon-owned ports, noting that UK ports are privately owned whereas European ports are predominantly state owned.

2.2.3 Gaps identified in project knowledge

Use of precise timing in maritime, requirements for autonomous vessels, and for autonomous port handling, detailed information on GNSS use on the land side at ports.

2.3 Delegate list Workshop 1: 15th May 2019

Delegate Name	**Employer**
Alan Tatman	
Alexander Darer	
Andy Norris	Dr Andy Norris
Asher Lawrence Cole	Department for Transport
Bob Cockshott	Knowledge Transfer Network (OWN ORGANISATION)
Daniel Morphew	BAE Systems
Daniel Ng	Cyberowl Limited
Don Cockrill MBE	
Dr Donough Wilson	Vivid/Futurevision
Fena Boyle	
George Shaw	General Lighthouse Authorities
Guy Buesnel	Spirent Communications Plc
Ian Stock	KTN
James Clark	Associated British Ports
James Whittaker	
Jens Hoxmark	
Jeremy Ward	University of Strathclyde
Johan Gahnstrom	
Kimberley Eastaugh	
Lal Dalamal	
Liz English	Associated British Ports
Mahmood Shafiee	Cranfield University
Mike Fairbanks	
Nancy Scotford	GrantTree Ltd
Nick Smith	

Nigel Mackie	
Raja Naeem Akram	Royal Holloway University of London
Rajesh Tiwari	Nottingham Scientific Limited (NSL)
Rakesh Pandit	Maritime and Coastguard Agency
Robert Orr	Context Information Security Limited
Robin George	Orolia / Spectracom
Simon Gaskin	
Stephen Clark	
Steven Bell	
Tim Alsop	
Toni Wilmot	
Vera Djepa	
Yeshpal Singh	University of Birmingham

3 MarRINav Stakeholder Dissemination Workshop

The second MarRINav stakeholder workshop was held on 5 December 2019 at the KTN in Islington, London. It disseminated the project results and received feedback from participants. It was open to the public without restriction and free of charge.

3.1 Workshop organisation

3.1.1 Objectives

The objectives of the workshop were to:

- Recap the aims of the project, its context and requirements.

- Report the principal results of the project, which included descriptions of:
  - candidate technologies for resilient and high integrity PNT within UK CNI;
  - conceptual geographical and operational architecture of the solution;
  - prediction of performance and potential service coverage areas;
  - outline cost benefit analysis;
  - roadmap to 2030+ of associated developments and activities;
  - outline development plan for a regional test-bed for proof-of-concept.

- Gather expert views and opinions from delegates to inform the future direction.

3.1.2 Delegates

The workshop gathered together 30 stakeholders from the maritime and position, navigation and timing sectors. Expertise in the room included:

- Commercial shipping
- Government and regulation in maritime
- Ports
- Mariners and pilots
- GNSS vulnerability and PNT resilience & integrity
- Cyber security
- Aids to navigation

3.1.3 Agenda

- Recap 0f the MarRINav project and its current status.
- Context and requirements for PNT performance, redundant, backup and contingency systems, including the approach to partitioning of integrity and continuity budgets across the system-of-systems components, for fault free and faulted conditions.

- Discussion of questions on integrity and continuity: How will needs evolve? What are the drivers for change? How will autonomy, digital ports and ships, e-navigation and data sharing affect these? This topic is discussed in documents D1 Context and Requirements, and D3 PNT Options.
- Candidate technologies for backup systems and their integrity and resilience.
- Discussion of questions on the user perspective: What are the barriers to users? What are the impacts on human factors?
- Navigation risk, conceptual architecture, service coverage.
- Discussion of navigational risk: Do participants perceive the same risks? Are risks adequately covered?
- Roadmap and initial development plan.
- Discussion of possible future test-bed: Is the tentative scope and location of the demonstrator sensible? How easily can it be scaled?
- Next steps to implementation (MarRINav phase 2?).
- Discussion of next steps: How to convince policy makers of the value of the solution?

3.2 Outcomes summary

The summary of participant discussion and feedback below is taken from facilitator notes:

1. Future drivers include:
   - Global warming.
   - Large LEO constellations (e.g. Starlink) possibly available be 2025.
   - Cyber-attack and electronic warfare.
   - Nation state attacks.
   - Maritime Autonomous Surface Ships (MASS) – regarded as a disruptive system.
   - Delegates showed considerable interest in trends and impact of jamming and spoofing.

2. Some vessels actually appear to navigate with an over-dependence on GNSS, despite mariners being trained to use all available sources of positioning and situational awareness information.

3. IMO requirements for continuity and integrity risk are expressed in terms of an operational continuity period which may in future be changed from 3 hours to 15 minutes; the 10s time-to alert limit may also need to be changed.

4. The maritime environment for GNSS signal reception on vessels (noise, multipath, interference) is recognised as more challenging than for aviation, varying from ship to ship and with the phase of the voyage.

5. Dual frequency multi-constellation receivers are now available. Their tolerance to local faults improves if RAIM and backup systems were to be integrated within them. Future addition of candidate resilient PNT technologies include:

- Multi-frequency multi-constellation GNSS integrated with Dead Reckoning.
- Ranging Mode (R-mode) of the VHF Data Exchange System (VDES), eLoran and Radar (perhaps aided by passive reflectors and eRacons on shore).

Signals-of-opportunity may be dependent on GNSS, and may therefore not be an independent backup. It was noted that DGPS signals may also need protection from spoofing, but this is outside the current scope.

6. Fault tree analyses for continuity and integrity must include local conditions, with multiple simultaneous faults (such as signal multipath and signal blockage/Non-Line-of-Sight reception) which are difficult to quantify and for which characterisation may require a very large set of real measurements.

7. There may be ~200 satellite signals available to fuse in the receiver's solution in the future timeframe to 2030+. Maritime receivers must be Type Approved to IEC test specifications reflecting IMO performance standards, but specific designs for fusion of multiple signals and multi-systems are not mandated and not openly published by equipment manufacturers. The IEC is at the beginning of a staged development of test specifications for various configurations of the multi constellation multi system receiver (MSR), starting with inclusion of maritime EGNOS/SBAS services.

8. The MSR will require Fault Detection and Exclusion (FDE) capability. This may include the integration of a GNSS interference detector, which could monitor signal characteristics such as signal-to-nose ratio (SNR) as a way of identifying faults. Making a fail-safe system from fail-safe components requires a rigorous safety engineering approach.

9. The Fault Tree Analysis of the MSR has assumed that backup and primary systems have the same performance requirements, but the introduction of a 'Resilience Factor' (R-Factor), expressing the percentage of time that a backup is used, provides a 'continuity credit' that enables overall continuity to be met in most practical contexts (subject to the incident rate and duration of jamming).

10. Visual aids (e.g. deploying ePelorus digital visual sighting), inertial navigation and traditional (speed log and gyrocompass) Dead Reckoning technologies should all be considered within the resilient PNT solution. Trends in costs and performance capabilities of suitable inertial systems should be monitored, but it was noted that affordable inertial units for vessels provide only limited hold-over capability of a few minutes after GNSS becomes unavailable. The advent of Quantum Technology clocks should be monitored and in future also the development of QT navigation. MarRINav results do not assume vessels carry accurate clocks, but if they were available the amount of shore-based infrastructure could be reduced.

11. International uptake on ships may need IMO to mandate carriage.

12. UK ports compete with each other (unlike European ports), which may complicate uptake of new techniques. It may be that technologies can be more easily introduced by Pilots, who may bring the necessary equipment into use in UK waters more readily than ports or vessels.

13. A UK-only approach to a resilient PNT solution could cause problems with international compatibility, although MarRINav has only considered candidate technologies within the scope of the IMO performance standard for the MSR. The technologies studied in MarRINav are also receiving significant attention in other parts of the world (e.g. US and Baltic Sea). Some techniques – such as ranging mode on other signals (e.g. NAVDAT transmissions) – can be discounted on this basis.

14. Skills shortages in the UK space and PNT sector may limit development of UK systems.

15. Maritime GNSS receivers only account for 0.7% of the GNSS market, limiting appeal to commercial suppliers – the solution might have to be sought through regulatory action rather than market forces.

16. Radionavigation risks from new offshore infrastructure are out-of-scope currently, but should be considered in future phases of MarRINav.

17. Firm support was expressed for a future test-bed for proof-of-concept demonstration of the PNT solution. Participants noted that:
    - Trials would need locations with appropriate VDES R-mode and eLoran transmitter sightline geometries.
    - Shipping companies have in the past been willing to participate in trials.
    - Support would be important for the UTC linkage from NPL's National Timing Centre for eLoran and VDES R-Mode synchronisation.
    - An interesting extension to terrestrial VDES R-Mode could be investigated through satellite VDES R-Mode, which it is understood may be addressed in another project with which MarRINav could collaborate.

18. A MarRINav solution could reduce UK economic losses by ~£420m for container traffic, assuming one 5-day outage in 10 years, mainly from reducing delays to manufacturing industries who rely on the flow of goods in the end-to-end maritime/land supply chain. Financially this could appear to be a hard sell, especially as beneficiaries from MarRINav may not be the funders. The central economic case for the MarRINav solution is strong but UK government may need to consider intervention so that costs are fairly partitioned.

3.3 Delegate list workshop 2: 5th December 2019

Delegate Name	Employer
Alan Grant	General Lighthouse Authorities
Andy Norris	Dr Andy Norris
Bob Cockshott	KTN
Christine Edwards	Sci-Tech Systems Ltd
Cliff Weatherup	Teledyn e2v
Don Cockrill MBE	
Dushan Kandasamy	
George Shaw	General Lighthouse Authorities
Ghulam Hussain	
James McLean	
James Slaughter	NLA International Ltd
James Whittaker	
Jeremy Ward	University of Strathclyde
Jonathan Goddard	
Jonathan Turner	NLA International Ltd
LC Hardy	
Marcus Ambler	Borwell Limited
Mark Dumville	Nottingham Scientific Limited (NSL)
Michael Fairbanks	
Natalie Gupta	
Nigel Mackie	
Peter Hall	Sci-Tech Systems Ltd
Rakesh Pandit	Maritime & Coastguard Agency
Remi Challamel	Thales Alenia Space UK Limited
Richard Greaves	NLA International Ltd
Robin George	Orolia / Spectracom
Ryan Manning	
Stefan Gewies	
Stephen Clark FRiN	
Steve Bell	
Tiree Macleod-Nolan	
Toni Wilmot	
Vera Djepa	
Wei Wei	

4 Conclusion

The MarRINav stakeholder engagement workshops have successfully disseminated key information on a UK approach to maritime resilient and high integrity PNT to a wide variety of interested parties, including: users, mariners, pilots, port and shipping operators and the wider PNT community.

Ten formal technical reports contain the project results and these will be made openly, publically available on the MarRINav website, once approved by ESA (expected at project close of Phase 1 in mid-January 2020). The workshops have shared the key findings from these reports. The MarRINav website will be maintained and updated, especially if a future phase of the project progresses to the development of a proof-of-concept demonstration with a regional test-bed.

The numbers, experience and backgrounds of workshop participants has been excellent in obtaining feedback on the maritime context and requirements, the technology options, their performance capabilities and the predicted service coverage area across the UK Exclusive Economic Zone (EEZ).

The MarRINav project team acknowledges the kind support of stakeholders and particularly wishes to express its gratitude to all external participants in the workshops for the valuable feedback provided.

Appendix 1: Engagement Plan

This document is an internal output from WP6, shared here openly for information. It defines the steps to be undertaken to engage, consult and inform MarRINav stakeholders and external interested parties on the aims and activities of the project, its outputs and subsequent follow-on work. This initial one-year phase is envisaged to be the first part of a three-year programme.

A.1 MarRINav objectives

- Collate thinking on resilient PNT options and solutions for UK sovereign capability
- Consider maritime resilient PNT to 2030+
- Use the UK as a case study, for maritime but also wider sectors
- Inform UK government policy on maritime PNT direction
- Consider eventual UK industry opportunities for solution export to other countries and international entities

A.2. Engagement objectives

During the engagement, we will:

- Share MarRINav objectives and results openly, consult as the project progresses and disseminate results
- Determine the state-of-the-art and direction of maturation of TRLs
- Focus on capabilities, but not review detailed technical specifications or promote specific commercial services or products
- Identify capability gaps accounting for degree of navigational risk
- Validate the MarRINav resilient and high integrity PNT solution approach and consult to ensure it meets community needs
- Identify priorities – what is essential, nice-to-have or not needed
- Identify risks to progressing a solution

A.3 Engagement targets

We will identify entities to engage with. Examples include:

- Maritime entities, e.g.
    - IMO, IALA, port operators – see attached list in section 8.
- PNT Technical Group and Blackett Report Implementation Group (BRIG)
- GSA, ESA, UK Space Agency

Consortium partners will be consulted on engagement targets and invited to suggest additions.

A.4 Engagement tools

- Email news letters
- Workshops
- Personal contacts

A.5 Supporting material to be developed in collaboration with partners

- MarRINav overview
- Newsletters
- Conference papers
- Workshop briefing notes for participants
- Workshop presentations
- Website

A.6 Workshops

The following steps are envisaged:

- Prepare list of invitees
- Issue invitations, including GDPR-compliant requests to allow future contact by MarRINav
- Plan workshop logistics (venue, catering, facilitation, rapporteurs, reporting)
- Prepare and issue briefing and preparatory material to participants
- Prepare presentation material, including speaker clearances for future dissemination
- Facilitate
- Record
- Analyse
- Prepare summary and conclusion
- Issue and disseminate report with conclusions
- Draft a project contacts list based on the workshop participant lists

A list of invitees will be produced, and, while KTN is responsible for delivering WP6, it may be more effective for partners to invite their contacts personally. KTN will therefore maintain a spreadsheet listing potential delegates, who is tasked with inviting them, and the progress of each interaction.

A.7 Summary of engagement outputs

- This plan
- Workshop invitations
- Workshop material
- Workshop reports
- Project contact list (GDPR compliant)
- Email newsletters
- Website content

A.8 Engagement target selection

This will be based on categories of relevant entities shown in figure 1 below.

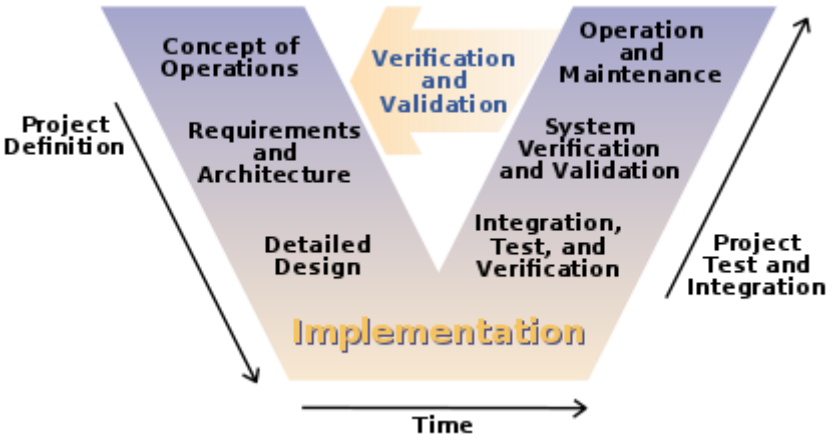

Figure 1 – Example of systems engineering V-diagram, from Wikipedia.

Based on these categories, the following examples of participant entities have been identified:

- Academia
- BIMCO
- Chambers of Shipping (UKCS, ICS)
- CPNI
- DfT and DfT Resilience Group
- ESA
- ESSP (EGNOS provider)
- Freight Forwarders
- European GNSS Agency (GSA)
- IALA
- IEC
- IFSMA (pilots)

- IMO
- IMPA (pilots)
- Intercargo
- Intertanko
- MCA
- Nautical Institute
- PNTC of techUK/UKSpace
- PNT Industry
- Port Authorities
- Port Operators
- Royal Academy of Engineering
- Royal Institute of Navigation
- RTCM
- Shipping Operators
- UKHO
- UKSA

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