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Network Innovation Competition Screening Submission Pro forma

Notes on completion

Before completing this form, please refer to the relevant Network Innovation Competition (NIC) Governance Document(s).[1]

Please use default font (Verdana size 10) in your submission and retain 1.5 line spacing.

We will only accept the text visible in the text entry areas.

The text entry areas are predetermined and should not be changed.

The full-completed submission should not exceed 19 pages in total.

Ofgem will publish all the information contained within this Screening Submission.

Is the application for the Gas or Electricity NIC? If a Cross-Industry Project, please state 'Cross-Industry'.
Gas NIC
Funding Licensee
National Grid Gas Transmission
Project Partners including other Licensees
DNV GL
Project Title
HyNTS FutureGrid Phase 1

[1] https://www.ofgem.gov.uk/publications-and-updates/version-30-network-innovation-competition-governance-documents All capitalised terms used in this document have the meaning given to them in the respective NIC Governance Document.

Project Summary			
The National Transmission System (NTS) is a key enabler to decarbonise the gas network in Great Britain (GB) in order to meet the government's target of net-zero emissions by 2050. The purpose of this project is to demonstrate that the NTS can be repurposed to carry hydrogen and can accelerate the decarbonisation of power, industry and heat by delivering a safe supply of energy to all customers both during, and after, the energy transition. This project will lead to a better understanding of what the technical parameters are around the ultimate role of the NTS in the energy system, and how the transition can be managed. National Grid Gas Transmission (NGGT) will feed the learning and outputs from previous NIA projects and the BEIS Hydrogen Programme Delivery Group (HPDG) into the creation of a NTS hydrogen test facility at DNV GL's Spadeadam testing and research site. NTS assets, due to be decommissioned in early RIIO2, will be reconstructed to create a test network that can be used to answer some of the fundamental questions around safety and operation of a converted network and inform later HPDG research requirements. Flows of hydrogen/natural gas blends, including 100% hydrogen, will be tested for the first time in GB at transmission pressures. This system will connect to the existing H21 distribution network test facility at Spadeadam to prove a complete beach-to-meter network can be decarbonised, supporting the HPDG goal to develop a comprehensive programme for the hydrogen transition. This project will provide a transmission facility which is a key facilitator for more advanced hydrogen testing on industrial equipment such as hydrogen separation technology, hydrogen-fuelled compressors and/or purification of hydrogen for transport.			
Estimated Start Date		**Estimated End Date**	
April 2021		April 2023	
Total Project Cost	£9.39m	**NIC Funding requested**	£8.45m
Technology Readiness Level (TRL) at start and end of project			TRL 4-6

What is the Problem that the Project seeks to address?
Net-zero was set into UK legislation in June 2019 and much attention has been placed on sectors such as heat which are difficult to decarbonise. The gas system is central to GB's current energy supply therefore it is the networks' responsibility to consider how to deliver reliable, low carbon energy to consumers in the most efficient way. The Energy Networks Association (ENA) report 'Pathways to Net-Zero' showed that a balanced combination of low-carbon gases and electricity is the optimal way to decarbonise and achieve 2050 net-zero emissions. Over the last 12 months, the gas networks have been working collaboratively under the HPDG chaired by BEIS to identify all the key issues and research required to prove that the current gas grid can be repurposed. A number of gas distribution projects are already under way (H100, H21, HyDeploy) and NGGT has been reviewing the role of the NTS which is vital for moving gas from entry points to directly-connected customers (power stations and industry), gas distribution network (GDN) offtakes and providing critical intraday linepack storage. As these projects develop, the gas networks are increasing efforts to coordinate and share information, including through HPDG and the hydrogen workstream in ENA's Gas Goes Green programme. A number of desktop studies have been undertaken through the HyNTS programme of work which have identified the potential for hydrogen in the NTS, however, a number of gaps in knowledge exist which are fundamental to, and underpin, the safe and reliable operation of a conversion. The Health and Safety Laboratory carried out an initial study and highlighted impacts such as leakage, venting and the effects on the mechanical properties of many materials. The main output of the research was that physical testing is required on a variety of NTS assets to understand the risks and mitigations before more advanced operational studies such as deblending can be undertaken. In Europe, GasUnie and SNAM, have already trialled hydrogen pipelines to test the impact on some assets. NGGT has not been able to identify a similar suitable pipeline and therefore determined that a facility constructed from repurposed NTS assets is the most effective way to understand the risks and demonstrate the capabilities of the transmission system. The output of this project will inform the BEIS HPDG programme for 2022 and provide "Priority RIIO2 projects related to the Local Transmission System (LTS) and NTS" to prove the whole GB gas network can be repurposed and decarbonised from entry point to the point of use.

What Method(s) will be used and why? Ie, what is being demonstrated or developed? Please describe in terms of the NIC eligibility criteria. (page 1/3)

This NIC proposal is phase 1 of NGGT's HyNTS FutureGrid Programme that seeks to prove that the NTS can be repurposed for hydrogen (see page 18 for the full programme).
Phase 1 will be divided into:

- Phase 1A to build a test facility at DNV GL Spadeadam.
- Phase 1B to test the compatibility and integrity of NTS assets with hydrogen blends up to 100% hydrogen.
- Phase 1C to update the NTS quantitative risk assessment (QRA) and safety case.

As with other projects of this scale, there will be a separate planning phase, prior to phase 1, during which the test facility will be designed and a master testing plan developed using NIA funding. The principles and specification of the test facility will be designed so that the facility can be built, and testing started, in a timely manner. The design will include the pipeline configuration, the assets to be tested, injection and mixing points, storage capabilities and flows. The master testing plan will incorporate a range of different scenarios for NTS operation which will seek to answer questions raised by our work to date and requests of the BEIS HPDG programme. The roadmap from the 'Hydrogen injection into the NTS' NIA study identified a range of existing NTS assets for testing between 55 and 94 bar(g) including:

- Pipes and welds covering the range of steels in the NTS
- Flanges with different gasket materials
- Bends
- Slam-shut valves and other safety critical mechanical devices
- Pressure regulation i.e. regulator and flow control valve
- Block valves and gas actuators (ball and plug type)
- Gas meters and analysis equipment
- Pre-heaters
- Filters and filtration

Flexibility will be built into the design so that future testing of technologies, such as blending/deblending and rotating machinery, can be included simply and efficiently in later phases of the HyNTS programme. Subsequent phases could also include testing the integrity and compatibility of other equipment and the use of the facility for developing staff competence through training.

What Method(s) will be used and why? (page 2/3)

Phase 1A will deliver an off-line NTS test facility constructed mainly from decommissioned NTS assets to demonstrate that hydrogen and hydrogen blends can be transported effectively, flexibly and safely in the existing network. This will substantially mitigate the risk of injecting hydrogen into the live NTS by closing the knowledge gaps. Key steps are:

- The relocation of a representative range of decommissioned NTS assets to DNV GL Spadeadam for assessment of repurposing these for hydrogen service
- The building, testing and commissioning of the NTS facility including hydrogen storage, hydrogen/natural gas blending and the link to the H21 distribution facility
- Developing safe operating procedures and risk assessments for the test programme

Phase 1B will deliver the master testing plan. Hydrogen will be injected and blended with natural gas to provide a range of compositions up to 100% hydrogen. There are likely to be strategic hydrogen concentrations including 10, 20 and 100% hydrogen with intermediate concentrations studied as necessary. Key steps are:

- Operating the NTS hydrogen facility for 6-12 months according to the master testing plan which may involve revisiting the plan in the light of the results
- Reviewing and evaluating the test results to assess the safe operation of the NTS and suggesting mitigations where possible
- Validating flow parameters such as gas velocities, pressures, energy delivery and other operating parameters for hydrogen blends up to 100% hydrogen

Phase 1C will use the data from phase 1B for a high-level assessment of the impact on public safety of a conversion of NTS pipelines to transport up to 20% hydrogen blends and 100% hydrogen. Since NTS pipelines are defined as Major Accident Hazard Pipelines (MAHP)s under the Pipeline Safety Regulations (PSR), NGGT is required to develop and maintain a Major Accident Prevention Document (MAPD) that demonstrates that all hazards have been identified, the risks have been evaluated and that an appropriate safety management system is place and kept under review. If results from phase 1B indicate that the failure frequencies of NTS components are different to those of natural gas, the new data will be used for the risk analysis. An initial review of key documents cited in support of the Safety Case has previously been undertaken.

What Method(s) will be used and why? (3/3)

However, the safety management system involves a large number of detailed procedures and work instructions. The suite of NGGT procedures will be triaged to prioritise each document for detailed review as either "High" (hydrogen likely to have a significant impact), "Low" (hydrogen unlikely to have a significant impact) or "Not required" (not affected by hydrogen). The main output from phase 1C will be a high-level comparison of the risk for 100% natural gas, a 20% hydrogen blend and 100% hydrogen. Risk will be presented as Societal Risk for the entire system with comparisons of the variation in Individual Risk with distance for typical pipelines. The comparison will be like-for-like and all other parameters (pipeline properties, operating pressures, etc.) will remain the same other than the hydrogen content of the gas.

We believe the above methodology will advance our knowledge and understanding into how future gas networks could safely operate and contribute significantly to defining the outstanding questions to be addressed by the HPDG future programme of work.

Funding Commentary (page 1/2) *Licensee must provide a commentary on the accuracy of its funding estimate. If the Project has phases, the Licensee must identify the approximate cost of each phase. If the NIC is being used as match funding, please state the other sources of funding.*

Cost of the project phases:

Phase 1A – Gather assets, build and commission (April 2021 – December 2021) £6.5m
Phase 1B – Conduct master test plan (January 2022 – September 2022) £2.2m
Phase 1C – Update the NTS quantitative risk assessment (QRA) and safety case for hydrogen (October 2022 – April 2023) £0.7m

Total project cost = £9.4m

Funding commentary:

NGGT has compiled the above quotation having taken advice from industry experts, previous experience of conducting NIC projects and from established unit-cost tools developed internally. For this reason, the cost accuracy is +/- 10% on the total.

Funding Commentary (page 2/2)

As with any construction at a transmission network scale, there can be considerable costs in the procurement, transport and installation of these assets and pipelines. The use of large diameter high-strength steel assets means that fewer items can be moved at once and increased costs are incurred when building civil engineering bases and supports to secure the parts in place. NGGT has made a commitment during this project that as much of the transmission facility will be constructed from recently decommissioned and redundant assets in line with our RIIO2 decommissioning strategy. In this way, since there are limited procurement costs, costs are reduced to transportation and fitting. Importantly, reusing decommissioned NTS assets also provides the advantage of being able to test how the various blends of hydrogen could impact our existing network. The offline transmission facility will reflect the online network assets with the only exception being the safety valves needed for operation which will be bought as new so they can be relied upon fully during the testing. By using redundant decommissioned assets, it is estimated £5m has been saved in procurement costs in this first phase.

NGGT uses recompression rigs in our current work practices but to compress natural gas only and reduce venting. The use of a recompression rig in the Spadeadam facility will reduce the amount of hydrogen and natural gas required to deliver our master test plan as the gas can be recycled in the loop and recompressed to transmission levels following the pressure reduction part of the facility.

Where possible, NGGT will look to partner with suppliers of the equipment that we will need; the transmission facility will act as a perfect test bed for new technology in a hydrogen future. To further develop this concept, NGGT believes that the facility will become a valuable asset for the UK to test any new innovative solutions for the NTS in a safe and controlled environment. Once the project is underway, NGGT will look to develop partnerships and, in return, those original manufacturers will supply their assets to the facility, further enabling innovation in the industry.

Our facility could also become the UK's first fully operational, transmission scale training site where NGGT staff, contractors and LTS operators can be trained on the differences of operating with hydrogen as opposed to the natural gas we are currently familiar with. This will also potentially attract other transmission service operators (TSOs) and assist in benchmarking and increasing the understanding of transporting hydrogen, globally.

Which specific requirements does the Project fulfill?		
Mark YES in the appropriate box(es)	**Electricity**	**Gas**
A specific piece of new (ie unproven in GB) equipment (including control and/or communications systems and/or software)		
A specific novel arrangement or application of existing electricity/gas transmission and/or distribution equipment (including control and communications systems software)		**Yes**
A specific novel operational practice directly related to the operation of the electricity/gas transmission and/or distribution systems		**Yes**
A specific novel commercial arrangement		

How does the Project accelerate the development of a low carbon energy sector and have the potential to deliver net financial benefits to existing and/or future customers in the relevant sector? (page 1/2)
This project will build on the learning from a number of desktop-based studies and provide a comprehensive test facility to generate the critical evidence required to operate the transmission system with hydrogen. The evidence to be gathered will be defined in the master test plan which sets out the necessary steps to prove that the NTS and its assets can operate safely and efficiently with hydrogen. Full hydrogen conversion of the NTS has the potential to be the cheapest route to the decarbonisation of heat by avoiding costly capital investment in a new transmission network which would ultimately be funded through consumer bills. The NTS delivers nearly 900 TWh of energy to Great Britain (including GDN's, industry, power generation and exports) which equates to 165.6 million tonnes of carbon dioxide. If this natural gas were replaced with green hydrogen, generated from renewable energy, all carbon dioxide emissions would be avoided. Similarly, if the natural gas were replaced with blue hydrogen (produced via steam reforming) 153.18 million tonnes of carbon dioxide emissions would be avoided each year (assuming current % efficiency of carbon dioxide capture).

Accelerates the low carbon energy sector (page 2/2)

Decarbonising the gas in the network can help to tackle the harder to reach sectors such as heat which contributes to a third of the UK's current carbon emissions. Decarbonising the NTS impacts other sectors too by encouraging industries to adapt to the different fuel type and decarbonise their own processes. The NTS also supplies gas to power generators and industry, therefore, hydrogen can help to decarbonise electricity and large-scale manufacturing. The NTS, with its nationwide coverage, could also provide large amounts of hydrogen to new refuelling stations around the country to support decarbonisation of transport. The full scale decarbonising of the UK transport industry is the subject of a collaborative NIA, led by Cadent looking at the transition of CNG fuelling to hydrogen.

Repurposing the NTS for hydrogen reduces the need for in-land steam methane reformers to produce hydrogen around GB and the associated transmission pipelines to remove carbon dioxide. The installation of methane reformers and later, electrolysers at coastal locations such as St Fergus and Grain LNG terminals is more likely to be achieved under planning regulations due to the existing land use, access to 'green' hydrogen from offshore wind farms, proximity to CCUS and a local skilled workforce. Conversely, more populated areas of GB will not be able to have such hydrogen production facilities nearby, therefore transportation of hydrogen in the transmission network to the distribution networks GB will be vital.

This project will address many of the key questions surrounding the introduction of hydrogen onto the National Transmission System and therefore will enable the power, industrial, heat and transport sectors to continue to have gas as a viable option during the transition. Conversion of the whole GB gas network to hydrogen will make a hugely significant contribution to the overall aim of net zero by 2050. The ENA pathways report, referenced earlier, states that the balanced scenario utilising decarbonised gas is lower in cost than the electrified scenario by £13bn/yr, equivalent to 12% of total energy system cost in 2050.

Without this project, the learning and decarbonisation achievable from a UK wide approach to hydrogen will be curtailed. The NTS is uniquely placed to rollout hydrogen delivery and decarbonisation at scale across Great Britain.

How will the Project deliver value for money for electricity and/or gas customers?
There are over 280,000 km of transmission and distribution pipelines delivering gas to over 20 million customers, including heating 84% of homes, meeting over 40% of the UK's industrial energy demand and providing around 40% of the UK's electricity generation. Whilst the electricity network supplies a base load of power it cannot meet the seasonal or intraday demand for heat therefore significant additional infrastructure would be required to replace the gas network which already provides this resilience. As the ENA pathways report referenced, delivering the net zero mandate by repurposing the gas network with low carbon hydrogen/natural gas blends will considerably benefit the GB energy customer by £13bn/yr. Continued use of gas will also ensure minimum disruption and costs to consumers in terms of new appliances and infrastructure as well as continuing to provide consumers with a choice of energy. Further, re-purposing the gas networks ensures that the existing infrastructure that GB consumers have already paid for continues to be utilised and avoids significant decommissioning costs. The proposed gas transmission test facility will be constructed from redundant assets which are planned to be decommissioned during RIIO 2 from the NTS, providing a cost saving of over £5m, versus procuring new assets. It will also benefit the industry more widely, as learning could be applied to the LTS operated by the GDNs, and to some directly-connected transmission customers due to similar construction materials and processes. Creating a single test facility using as many transmission assets as possible, will also remove the need for separate test projects to address each individual asset in isolation. Additionally, several lengths of 48" NTS pipeline, which are being used on the collaborative H21 NIC project for hydrogen storage will be further used for this NIC project, again reducing costs overall. Finally, innovation from previous NGGT NIA projects will also be used to support this project such as composite pipe supports which could create cost savings and demonstrate their potential for the network of the future.

How will the Project generate knowledge that can be shared amongst all relevant Network Licensees?
There are several key areas of learning that will be delivered by this project which will be of interest to the other gas networks: 1) This project will inform the Gas Distribution Networks (GDNs) about how hydrogen could be provided to the NTS offtakes across the country in the future and, additionally, how the local transmission systems could operate, as they are built from similar materials and have a similar heritage. 2) It will provide a test facility for technology organisations and other industrial users to trial and demonstrate their equipment for use with hydrogen in a safe and controlled scenario, further supporting the energy transition. Additionally, the gas transmission facility will offer the opportunity to train staff in the operation and maintenance of a hydrogen network. 3) Outside of the GB network licences, this project will have a far-reaching impact on global efforts to decarbonise transmission networks helping GB to remain a world leader. Our current network is connected to the wider European transmission grid and working collaboratively to address the concerns raised will increase the pace of change for all. NGGT and the project steering committee will prepare project progress reports as outlined in the NIC governance to identify all relevant knowledge gained during the project. These reports will be published on the Smarter Networks Portal and details will be sent to all GB network licensees. Project progress will be reported through a strong online presence including video, social media, webinars and interactive web-based engagement. Results and project learning will also be reported at targeted events and conferences throughout the project, with the potential for a number of significant overseas conferences. Key project updates will feature in NGGT's annual Network Innovation report and on its corporate website. There will be global interest in this project as it will be one of the few facilities for testing technology and assets for hydrogen at high pressure gas transmission operating conditions.

Answering Yes or No, does the Project conform to the default Intellectual Property Rights (IPR) arrangements set out in the NIC Governance Document? *If answer is NO, the Licensee must demonstrate how learning will be disseminated to other relevant Licensees and how value for money will be ensured. The Licensee must also outline the proposed alternative arrangements and justify why the arrangements are more suitable than the default IPR arrangements.*
Yes

How does the project demonstrate it is innovative (ie not business as usual) and has an unproven business case, that the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness?
There have been several desktop studies funded through NIA which have been completed under the HyNTS programme of work, These include projects such as Project Cavendish, Aberdeen Vision and the Hydrogen Injection into the NTS, which can all be found on the Smarter Networks Portal. These desktop studies have generated a strong base of knowledge from which to build and much of this learning has been built into the HPDG considerations for future research. All the studies and research to date highlight that the transmission system cannot be operated with hydrogen until key knowledge gaps have been addressed and policies and standards updated to reflect amended ways of working. Many of these tasks are impossible to address without physical trials at scale to resolve the knowledge gaps and develop suitable mitigations. In addition to the technical aspects the business case for hydrogen transportation in GB has been the focus of our studies and is also the subject of increased interest from our customers e.g. power stations who are reviewing their opportunity to decarbonise. NGGT has been unable to identify a suitable section of pipework where these tests could be demonstrated safely without impacting consumers supplies on the live network, therefore we are proposing an offline facility constructed from decommissioned assets. This project will provide a fully representative gas transmission network and will be the first of its kind to fully expose NTS assets to hydrogen blends up to 100%. The facility will provide for an unprecedented level of hydrogen testing to gather the empirical data to address any concerns and prove the NTS can be safely repurposed for transportation with hydrogen. This facility can also be a focal point for others to carry out testing on hydrogen thus unlocking the ability for further collaborative innovation. Without this crucial step to develop a gas transmission test facility the whole GB gas network will not be able to be decarbonise in a low cost, non-disruptive way and thus will not be able to reduce carbon emissions to meet the net zero target.

How were Project Partners, external resources/funding identified, and what are their respective roles in the Project? Please evidence how Partners were identified and selected, including the process and rationale that has been followed. *The Licensee should provide details of any Project Partners who will be actively involved in the Project and are prepared to devote time, resources and/or funding to the Project. If the Licensee has not identified any specific Project Partners, it should provide details of the type of Project Partners it wishes to attract to the Project.*
National Grid Gas Transmission carried out a competitive tender for strategic consultancy to deliver the 'Hydrogen injection into the NTS' NIA project. This was awarded to DNV GL based on the existing knowledge of our asset base and current safety case. DNV GL also has years of legacy experience from the early British Gas period to the current period with the National Grid Gas Transmission network and fully understands the assets. As part of this project DNV GL identified a future roadmap of projects required ahead of a live trial, gaps in the safety case and gaps in the NTS knowledge of testing hydrogen with NTS assets. As reported during this NIA, whilst a hydrogen injection project was feasible on the transmission network there were still many challenges about the impact that up to 100% hydrogen may have on the assets. It was decided that these challenges should be addressed first offline before live online trials were attempted. DNV GL operates an established test facility at RAF Spadeadam in Cumbria and they have extensive experience in testing equipment for the wider gas industry in a secure, safe and controlled environment. They also have access to the expertise needed to build the transmission facility using existing decommissioned NTS assets in an offline, but 'live', scenario enabling a full and comprehensive test plan to be carried out to prove the safety case for transporting up to 100% hydrogen. The H21 Phase 2 project is currently utilising the Spadeadam test facility to build their distribution array upstream of the DNV GL funded and completed HyStreet project of a terrace of three houses and involved in the Hy4Heat project. The transmission facility will be connected to these projects to create a complete beach to meter test system to represent future GB gas infrastructure. Other partners such as compressor suppliers or deblending equipment providers from our recent collaborative NIA may also be involved in future phases of this project.

Would the Project require any derogations or exemptions to current regulatory arrangements? *If YES, please provide details of the required changes.*
No derogations, exemptions or changes to regulatory requirements are required.

How will the Project activities impact customers? *The Licensee should outline any planned interaction with customers or customers' premises as part of the Project, and any other direct customer impact (eg amended charging arrangements, supply interruptions).*
This project will not directly impact customers as it is an offline facility of NTS assets. It will link with the offline H21 distribution facility and HyStreet at the DNV GL research and test site at RAF Spadeadam to prove the complete beach to meter scenario. It will provide customers with the knowledge and reassurance that the NTS is safe and capable of delivering hydrogen or a blend of hydrogen, to suit their position on the energy transition. Customers for the NTS are power generators, industry and the GDNs offtakes – this project will enable all three to plan for a decarbonised future.

This question is for Cross-Industry Projects only. What funding is being requested from each NIC? Please include justification for the funding split.
N/A

Are there any further details the Licensee considers would support its submission?
This project proposal forms part of a larger programme of work proposed by NGGT that will allow focus on some of the bigger questions in the BEIS Hydrogen Programme. **Planning Phase -** The principles and specification of the test facility will be designed through an NIA project so that the facility can be built, and testing started, in a timely manner. The design will include the pipeline configuration, the assets to be tested, injection and mixing points, storage capabilities and flows. **Phase 1 –** HyNTS FutureGrid; using decommissioned NTS assets to build a complete NTS demonstrator that allows the testing of Entry and Exit Points, Filters, Valves, Meters and Pre-Heaters with 10%, 20% and 100% hydrogen in Natural Gas. The demonstrator will connect to the existing H21 distribution testing facility providing a representative 'beach to meter' set up. This forms the proposal detailed in this ISP. **Phase 2 –** HyNTS FutureGrid; will look to trial gas separation technologies such as cryogenics and membrane separation to demonstrate the capabilities to transport a hydrogen/natural gas blend and separate these into pure hydrogen or pure natural gas providing flexibility to customers. Additionally, assess the impact on rotating machinery of transporting and processing hydrogen and testing the capability and impact of driving the compressors using hydrogen as the fuel source. Later phases will focus on making the test facility open for a wider range of third party testing, operating a number of innovation projects that allow manufacturers to trial new technologies and assess the impact of hydrogen on their assets. Examples include in-line inspection, maintenance practices, metering and the opportunity for previous NIC projects to undertake testing such as a CLoCC connection and operating the Gas Robotic Agile Inspection Device (GRAID) in a future hydrogen environment. This facility could also be potentially used or adapted for future testing of carbon dioxide transport at transmission level. Statements of support have been received from all Network Licensees, Gas Networks Ireland and GTC.

Contact Information (Cross-Industry Projects can provide two contacts)

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