Request for Research Funding for FY 2020-2021			
Requesting Office	Planning – Office of Policy Planning	**Priority**	1 of 8
Proposed Title	Incorporation of Climatic and Hydrologic Nonstationarity and Deep Uncertainty into FDOT Planning and Design Guidelines & Processes		
Justification	Planning for agile, resilient, and quality transportation infrastructure (TI) requires moving from a stationarity assumption (past climate indicates what is to be expected in the future) to a nonstationary environment characterized by rising sea levels, changing rainfall patterns and floods, stronger and/or more frequent tropical storms, changing land use/land cover, and rising groundwater tables. While guidance documents such as HEC-17 (guidance for riverine systems) provide enhancements to consider nonstationarity, their application to Florida's situation requires the development of specific approaches, guidelines and data sets and extend them to coastal environments. Currently, the "Design Return Period" concept is the standard practice, but recent research on nonstationarity indicates that this concept needs to be revisited as the return period, and future risks themselvess, are dynamic (Salas et al. 2019*). A new paradigm which incorporates changing failure probabilities, risks, and innovative planning criteria based on future projections is needed. In addition, since future conditions due to climate change are highly uncertain, or even deeply uncertain (e.g. sea level rise scenarios), a prudent strategy, such as Dynamic Adaptive Policy Pathways (DAPP), that accounts for this uncertainty is required for ensuring resiliency of ongoing and future transportation infrastructure. In this approach, a project is not implemented fully at the beginning of the design life but rather contemplates a carefully planned phased implementation that is conditioned on tipping points when the environmental conditions change. This approach also explores alternative sequences of decisions for multiple futures and illuminates the path-dependency options. This is followed by an evaluation of all the pathways to identify short-term solutions that are actually low-regret but keeps the options open for implementation later when warranted. * Salas, J.D., J. Obeysekera, and R. Vogel. 2018. Techniques for assessing water infrastructure for nonstationary extreme events: a review. Hydrologic Science Journal, Vol. 63, Issue 3. Published online: 27Feb2018		
Impact	The impact of longer-term climate and anthropogenic changes in different flooding drivers is rarely been accounted for in the design and planning of coastal transportation systems. Starting from HEC-17 (and HEC-25), this research will provide specific methodologies and data sets for planning TI experiencing changing stresses and shocks from climate and associated impacts but customized for Florida. Incorporation of a new paradigm for TI planning that is based on actionable science on changing conditions such as rising sea levels, changes in storminess (affecting storm surges and waves), increasing extreme rainfall, and in some cases rising groundwater levels, will lead to innovation in resiliency planning that will ensure sustainability of transportation infrastructure for many decades. The methods and data sets developed as a part of this research will be incorporated into the tools of the UF GeoPlan sketch planning tool maintained by the University of Florida. The proposed DAPP approach which will complement the nonstationary approach has the potential to enhance the current approach of design-build to provide the level of service for a pre-determined design life (e.g. 50 years) expecting the project to serve during the entire period. While this approach may be appropriate under stationarity condition, it does not work well when the future predictions (e.g. rainfall, sea level rise, land use changes) are deeply uncertain. The DAPP for a transportation project includes a careful assessment of multiple plans which are dynamic, considers tipping points when a current plan may need to be enhanced or modified as environmental conditions change with time. For instance, roadway bed may be designed for the entire design life considering future scenarios, but the road surface would be constructed only up to a certain elevation consistent with the level of existing flooding in the near term. In this example, retrofitting of the roadway is envisioned upfront and the initial plan and design would already incorporate such a project when a tipping point (e.g. increasing frequency of flooding due to King Tides) is reached. The DAPP approach can explicitly account for lifecycle costs and benefits but requires less initial investments and allows the postponement of future investments which are tied to changing conditions and tipping points.		
Affected Offices	This proposed project will potentially benefit a wide range of FDOT Offices and stakeholders, including: • FDOT Office of Policy Planning • FDOT Forecasting and Trends Office • FDOT Systems Implementation Office • FDOT Office of Environmental Management • FDOT Emergency Management Office • FDOT Office of Design • FDOT Maintenance Office • FDOT Districts • Florida's Metropolitan Planning Organizations		

	• Various local city and county departments and regional planning councils throughout the State of Florida		
Existing Work	A review of the Transportation Research International Documentation (TRID) and the Research in Progress (RIP) databases did not indicate any research on incorporation of nonstationarity into planning and design of transportation infrastructure in Florida or incorporation of dynamic adaptive pathways for transportation projects.		
Keywords Used In Existing Work Search **(Cannot leave blank)**	Nonstationarity, Climate Change, Sea Level Rise, Risk, Return Period, Recurrent Flooding, Dynamic Adaptive Pathways, Deep Uncertainty		
Related Contracts (Give contract numbers)	Similar research has been conducted in other fields of civil engineering, particularly in water resources. But there is no similar current or prior research on assessing and including nonstationarity or dynamic adaptive policy pathways in transportation infrastructure planning.		
Funding Request	$500,000 (phased)	**Anticipated Duration**	36 months
Project Manager	Jennifer Carver	**Contracting Method**	Direct contract with Florida International University (FIU may provide subawards to UCF and UF)
Urgency	Score 1	Changes in climate and associated extreme weather events are already affecting Florida's coastal communities and infrastructure. Most notably, the frequency of high tide flooding events in cities like Miami has increased significantly as a result of sea level rise and is projected to increase further in the next few years and decades. This also has a direct effect on elevated ground water tables. Changes in storm surges and extreme wave events will be a direct consequence of any changes in the intensity, frequency, or tracks of tropical and extra-tropical storms. In the recent years, places such as South Florida have experienced unprecedented rainfall from both tropical and non-tropical system causing significant damages to TI and other infrastructure. Hence, as impacts from these climatic changes to transportation infrastructure are already evident, and are projected to get worse in the future, including nonstationary into improved design guidelines for more resilient TI is of utmost urgency, in particular for Florida. There is also an urgent need to revisit the current TI planning approach to account for deep uncertainty in climate projections (including sea level rise, rainfall) and land use changes.	
Implementability	Score 1	Similar research has already been conducted for other engineering fields, such as water resources planning and management, which can be leveraged and used as starting point for the proposed work, but with a particular focus on the situation in Florida and improved TI resiliency and planning in mind. Data sets (first of all observations, but also reanalysis and model hindcasts) of the different flood drivers are readily and publicly available to be used in the development and testing of the proposed nonstationary extreme value analysis tools and risk assessment. Using few pilot projects, the use of dynamic adaptive policy pathways approach will be demonstrated, and a capacity building component of the research will train FDOT personnel regarding its implementation.	

Project Benefits (Succinct, complete explanation)

The proposed project and its outcomes will lead to the improvement of existing guidelines by adding specific methods to consider nonstationarity in coastal ocean levels, changing rainfalls and flood regimes and an innovative approach for incorporating future uncertainties (e.g. climate) into planning and design of transportation projects. The proposed project will begin from existing guidelines (e.g. HEC-17 and HEC-25) and develop specific methods and datasets specific to the State of Florida. The approach will also develop a smart investment strategy, envision future retrofits or alternative plans upfront that are based on tipping points of environmental conditions. The tipping points allow consideration of the lead time necessary to plan project retrofits and upgrades.

The outcomes of the nonstationarity approach and the dynamic adaptation will be recommended for progressive inclusion in the current FDOT planning and design guidance documents. This will allow the research team time to build capacity among the engineers incorporate the new approach only when FDOT is comfortable with the proposed changes. In a changing environment of rising sea levels and changing rainfall extremes, the future designs of roadways and other infrastructure will be more robust and will continue to serve the design life since they incorporate the anticipated climatic risk that is expected in the future.

Project Benefits **(Select all that apply and explain)**	**Quantifiable Benefits (units, dollars, etc…if applicable)**	**Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits**
○ Materials Enhancement		
○ Materials Savings		
○ Time Savings		
○ Lives Saved/Injuries Prevented		
○ Other (Explain)		1. The proposed work will put FDOT in a position that allows them to incorporate nonstationarity of different flooding drivers into innovative design guidelines. 2. Identifying variables where nonstationarity is already evident in the observational records (e.g. sea level) and projecting those into the future (either based on past observations or by leveraging downscaled climate model outputs) will help identify key drivers of changes in flooding risk for TI, which need to be mitigated through improved design. 3. Knowing the current state of the system and expected future changes in design relevant quantities will allow identification of possible adaptation tipping points in the (near) future, and hence provide guidance on the timelines when revised policies and design standards should be implemented.

*Comments should explain and support urgency, financial benefit, and implementability scores